30589
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Release 257
10/80

One of the
DUMONT
400
Series

TYPE 404 & 404-R PULSE GENERATORS

OPERATION • MAINTENANCE

Printing Produced by
The George R. Epple Co.
Somerville, N. J.

30589
SKSTE

DU MONT

PULSE GENERATORS

TYPES 404 and 404-R

Allen B. Du Mont Laboratories, Inc.
TECHNICAL PRODUCTS DIVISION

760 BLOOMFIELD AVENUE, CLIFTON, N. J., U. S. A.

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ALLEN B. DU MONT LABORATORIES, INC.
TECHNICAL PRODUCTS DIVISION
Clifton, N. J.
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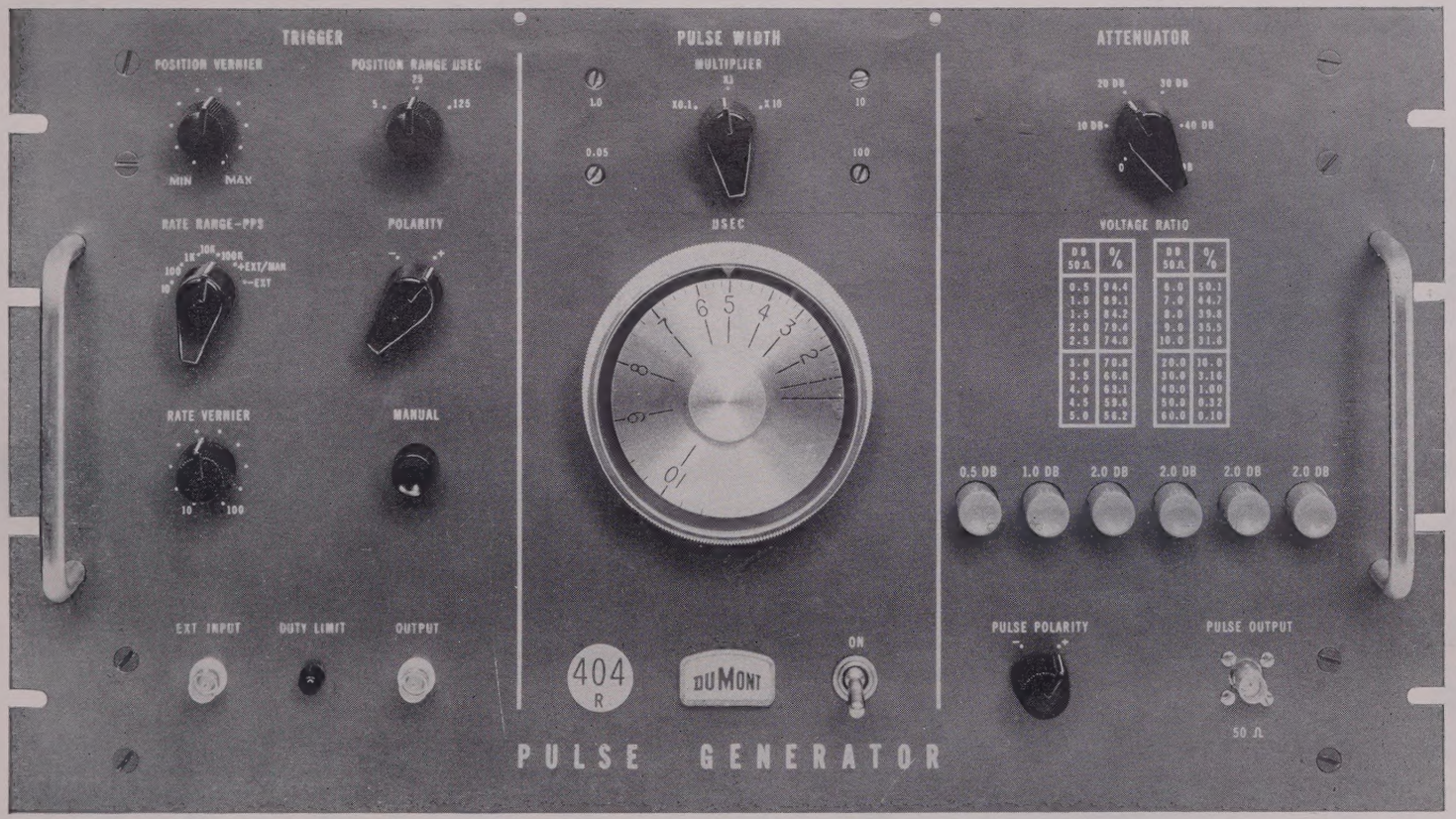


Figure 1-1. Type 404-R Pulse Generator

SECTION 1
TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions contains information on both the Type 404 (bench model) and Type 404-R (rack mounted) Pulse Generators. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 404 pertain also to the Type 404-R.

1-2. PURPOSE

The Type 404 is a general purpose Pulse Generator providing good-quality pulses of useful level for most applications. This instrument generates pulses ranging in width from 0.05 microsecond to 100 microseconds, with repetition rates up to 100K pulses per second at combinations of pulse width and repetition rate up to the automatic duty cycle limit of approximately 10%.

1-3. FEATURES

- Good-quality pulses variable in width from 0.05 to 100 microseconds.
- Repetition rates from single pulse operation (MANUAL) and continuously variable from 10 to 100K pulses per second (internal or external initiation).
- Positive overload protection eliminates danger of damaging the instrument, regardless of control setting.
- OUTPUT trigger available to initiate external equipment before or after pulse start with negligible jitter.
- Precision ladder attenuator, controls pulse amplitude in 0.5 db increments, from 0 attenuation to 59.5 db down.
- PULSE OUTPUT start can be advanced up to approximately 2 microseconds or delayed at least 125 microseconds with respect to the delayed trigger OUTPUT.

TABLE 1-1
TECHNICAL SUMMARY
DU MONT TYPES 404 AND 404-R PULSE GENERATORS

1. PULSE OUTPUT	
a. Amplitude	
1) Peak voltage[1]	50 volts ±10% with 50-ohm termination (+10%, −20%)
2) Overshoot	3% maximum above steady state value
3) Flat top irregularities[1]	±1% maximum referred to steady state (±5%)
4) Droop[2]	5% maximum for all positive pulses; negative pulses up to 10 microseconds wide
Attenuation	ATTENUATOR enables reduction of pulse amplitude in 0.5 db increments to 59.5 db
Incremental accuracy	±3% each step of the ATTENUATOR
b. Polarity	Switched positive or negative
c. Output Impedance	Through attenuator, 50 ohms ±3%; unattenuated, 30 to 55 ohms source impedance depending on operating conditions
d. Duration	
1) Width[3]	0.05 to 100 microseconds; 0.1 to 100 microseconds in three calibrated ranges, ±10% full scale accuracy; 0.05 USEC minimum setting front panel adjustment
2) Rise time	18 millimicroseconds nominal, 20 millicroseconds maximum
3) Fall time	20 millimicroseconds nominal, 25 millimicroseconds maximum
4) Duty cycle	9% to 12% automatic duty limit protection; optimum performance, 5%

TABLE 1-1. TECHNICAL SUMMARY (Continued)

e. Initiation

1) Internal	10 pps to 100,000 pps ±5%, continuously variable in 4 overlapping ranges
2) External	Can be triggered by pulses having the following characteristics: Amplitude: from 4 to 100 volts peak Polarity: positive or negative Rise time: 1 μsec or less Rep rate: single transients to 100,000 pps
3) Manual	Push button provides single pulse of selected width and amplitude

2. TRIGGER OUTPUT

a. Rise Time	0.1 microsecond maximum
b. Amplitude	10 volts minimum into 100-ohm load
c. Width	0.05 to 0.2 microseconds
d. Polarity	Switched positive or negative
e. Jitter With Respect to PULSE OUTPUT[4]	4 millimicroseconds or 0.1% of delay, whichever is greater
f. Delay With Respect to an External Trigger	6, ±1 microseconds, fixed, measured at 50% points

3. PULSE POSITION

a. PULSE OUTPUT With Respect to Trigger OUTPUT	Internal, external, or manual operation, pulse start can be advanced up to 2, ±0.6 microseconds or delayed up to at least 125 microseconds, continuously variable in three ranges within pulse delay duty cycle limits
b. Delay of PULSE OUTPUT With Respect to an External Trigger	Less than 5 microseconds to beyond 125 microseconds (measured with respect to the 10% point on the leading edge of an external trigger) as limited by pulse delay duty cycle
c. Pulse Delay Duty Cycle	75% (duration of pulse delay period defined as sum of fixed trigger delay and pulse delay) for example, at a repetition rate of 100,000 pps, PULSE OUTPUT start can be delayed up to 1.5 microseconds maximum with respect to delayed trigger output; maximum repetition rate at 125 microseconds pulse delay is 6000 pps. Exceeding duty cycle will cause erratic pulse performance

4. POWER REQUIREMENTS

a. Primary Source	115/230 volts, ±10%
b. Primary Frequency	50-60 cycles
c. Power Consumption	600 VA

5. SIZE AND WEIGHT

	Type 404	Type 404-R	
		Behind panel	Panel
a. Height, inches	11-3/8	10-1/4	10-15/32
b. Width, inches	17-5/8	16-7/8	19
c. Depth, inches (includes knobs)	16-1/2	15-7/32	
d. Weight, pounds	55	55	

NOTES

1. For duty cycle of 5% or less. Certain characteristics may change when operating with pulse duty cycle from 5% to 10%. Where applicable, the changed characteristics are shown in parenthesis.
2. Applies to negative pulses wider than 10 microseconds only after suitable operating time under wide negative pulse conditions.
3. Pulse widths less than 1 microsecond may be affected by repetition rate at high rates.
4. Applies to high-frequency jitter resulting from ripple and noise.

SECTION 2
OPERATION

2-1. GENERAL

The Du Mont Type 404 and 404-R Pulse Generators are shipped with all tubes in place and ready to operate.

Since these instruments are portable, no special installation procedure is required. The —R model has a front panel 19 inches wide by 10½ inches high for mounting in a standard relay rack or cabinet.

2-2. ENERGIZING THE EQUIPMENT

To place the instrument into operation, plug the power cord into the proper power source and turn the power switch to ON. Allow approximately one minute for the instrument to warm up.

2-3. OPERATING HINTS

a. General

The operation of this unit is very simple. Connect a length of 50-ohm cable with a BNC plug at one end to the PULSE OUTPUT terminal. The other end should be terminated with a 50-ohm resistor either by the load impedance of the circuit receiving the pulse or by means of an appropriate terminating connector. Pulse width, amplitude, delay, and repetition rate are set according to the desire of the user.

b. Cables and Termination

When dealing with fast, high quality pulses, the importance of impedance matching cannot be overemphasized. Interconnecting cables used with the Type 404 Pulse Generator must have 50-ohm characteristic impedance and must be terminated with a pure 50-ohm resistance in order to preserve optimum pulse waveform.

The method of termination and interconnection is also important. All junctions should be made up of coaxial plugs and connectors. Terminations should also be coaxial, even to the extent of using "T" connectors to provide plugged on terminations with a minimum of discontinuities. Failure to observe these precautions can result in severe distortions of pulse waveshape.

c. Checking Pulse Width

The complete pulse width calibration procedure is given in Maintenance, Section 4. However, reference to this procedure should be resorted to only if the in-

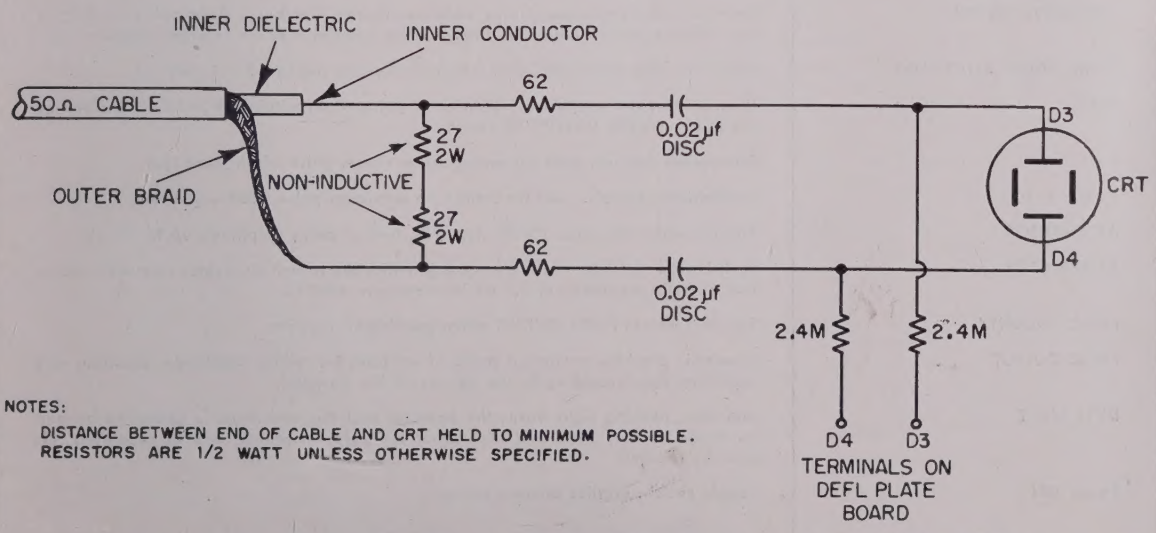


Figure 2-1. Method for Viewing Pulses Direct at Cathode-ray Tube Plates

strument does not check out satisfactorily as indicated below:

1) Connect properly terminated cables between trigger OUTPUT and the external sync terminal of a cathode-ray oscilloscope; and between PULSE OUTPUT and the vertical input of the oscilloscope.
2) Turn the μSEC dial to 1 and note that the pulse width is 0.1, 1, and 10 microseconds when the PULSE WIDTH MULTIPLIER is switched to X0.1, X1, and 10 positions respectively.
3) Turn the μSEC dial to 10 and note that the pulse is 1, 10, and 100 microseconds when the PULSE WIDTH MULTIPLIER is switched to X0.1, X1, and 10 positions respectively.
4) Finally, it should be possible to obtain a 0.05 microsecond pulse when PULSE WIDTH MULTIPLIER is set to X0.1 by turning uSEC

TABLE 2-1
FRONT PANEL FACILITIES

NAME	FUNCTION
(TRIGGER) POSITION VERNIER	Control: used in conjunction with POSITION RANGE switch to permit continuous adjustment of the start of the OUTPUT PULSE with respect to the fixed trigger OUTPUT signal
(TRIGGER) POSITION RANGE μSEC	Switch: used in conjunction with POSITION VERNIER control to provide three overlapping ranges for adjusting the start of the OUTPUT PULSE
RATE RANGE—PPS	Switch: performs three functions—1) selects the internally generated triggers in decade steps from 10 to 100K pulses per second, 2) sets up the instrument for amplifying signal applied to EXT INPUT when switch is set to +EXT/MAN or —EXT, and 3) permits the instrument to be driven manually when switch is set to +EXT/MAN
RATE VERNIER	Control: provides continuous variation of the internal repetition rate within the limits established by the RATE RANGE—PPS switch
POLARITY	Switch: switches the fixed delayed trigger OUTPUT either positive or negative
MANUAL	Push-button switch: provides single trigger and pulse of selected width and amplitude when instrument is set for manual operation
EXT INPUT	Terminal: input point for external triggers
(TRIGGER) OUTPUT	Terminal: provides a positive or negative trigger, that has a fixed delay of 6, ± 1 μsec with respect to either the internal rate generator or an external trigger
PULSE WIDTH MULTIPLIER	Switch: multiplies the μSEC dial settings in decade steps of 0.1, 1, and 10
μSEC	Control: provides continuous variation of pulse width within the limits established by the PULSE WIDTH MULTIPLIER switch
0.05	Screwdriver control: used for setting up minimum pulse width—see text
1, 10, & 100	Screwdriver controls: used for setting up maximum pulse width—see text
ATTENUATOR	Rotary switch: provides 10 db step reduction of pulse amplitude up to 50 db
ATTENUATOR	Push-button switches: used in conjunction with the rotary attenuator to enable reduction of pulse amplitude in 0.5 db increments to 59.5 db
PULSE POLARITY	Switch: switches PULSE OUTPUT either positive or negative
PULSE OUTPUT	Terminal: provides an output pulse of controllable width, amplitude, position, and repetition rate according to the desires of the operator
DUTY LIMIT	Indicator: flashing light warns the operator that the instrument is operating beyond its maximum duty cycle and that either the pulse amplitude and/or repetition rate must be reduced
Power ON	Toggle switch: applies primary power

dial fully counterclockwise and/or by turning the 0.05 μSEC Pulse Width control counterclockwise.

d. Direct Connection To Deflection Plates (See Figure 2-1)

When applying pulses directly to the deflection plates of a cathode-ray tube, the shape of the pulse is not limited by the response of the built-in amplifier. Instead, it is dependent upon transmission line losses, input capacitance to the deflection plate terminals and transit time of the electron beam. The need for proper termination is accentuated when viewing pulses direct on high-impedance deflection plates. In many cases, using the deflection plate terminals provided by cathode-ray oscilloscope manufacturers is unsatisfactory because of the long leads from the terminal board to the deflection plates. Figure 2-1 indicates the proper hook-up for viewing pulses directly at the deflection plates of a cathode-ray tube

2-4. FRONT-PANEL FACILITIES

The front-panel markings are essentially self explanatory, and after reading Table 2-1, the operator should be able to master the controls with a minimum of practice.

SECTION 3
THEORY OF OPERATION

3-1. GENERAL

The Type 404 Pulse Generator uses hard tubes for pulse generation. This instrument features repetition rates of 100,000 pulses per second; pulse widths from 0.05 to 100 microseconds, continuously variable; approximately 20 millimicroseconds transition time; and 50-volt output across a 50-ohm load with provisions for accurate control of amplitude in 0.5 db increments, up to 59.5 db.

An over-all functional block diagram of the instrument is shown in Figure 3-1 and a simplified timing diagram in Figure 3-2. It is recommended that the schematics at the rear of the manual be referred to in following the circuit description. For information on service adjustments, refer to Maintenance, Section 4.

To simplify circuit analysis, the instrument is divided into five basic sections as follows: (1) Synchronizer, (2) Timing and Pulse Generator, (3) Pulse Driver and Output, (4) Attenuator, and (5) Power Supply and Heaters.

3-2. SYNCHRONIZER

a. Internal Trigger Operation

The purpose of the synchronizer is twofold: 1) to produce a reference or starting trigger at time t_0 for subsequent initiation of the instrument, and 2) to produce an OUTPUT trigger having a fixed delay of approximately 5 microseconds with respect to the trigger at time t_0.

The internal rate generator (V101A & V101B) is a free-running multivibrator. Waveform **A** at the plate of this stage is differentiated by C115 and R114 and is clipped by CR101, resulting in waveform **B.** The leading edge of waveform **B** is coupled through the series triggering diode (V103A) to the output trigger delay multivibrator (V104) which generates waveforms **C** and **D.** Waveform **D** at the cathode of V104 has a fixed duration of approximately 5 microseconds and is differentiated by C119 and R123. The delayed positive trigger of waveform **E** is used to initiate a blocking oscillator (V105 and T101) which generates waveform **F.** Waveform **G** is the fixed delayed trigger OUTPUT occurring at time t_1, and is switched positive or negative by the POLARITY switch setting.

b. External Trigger Operation

When the RATE CHANGE—PPS switch is set to —EXT or +EXT/MAN, V101A and V101B are converted to a two-stage amplifier for amplifying signals applied to EXT INPUT.

V102A functions as a phase splitter and is switched into the circuit to precede the external trigger amplifier (V101A & V101B) when the instrument is set for external triggering. The phase splitter is operated as a class "A" amplifier with equal plate and cathode loads for equal positive and negative outputs. For external trigger operation, the output of V102A must always be negative in order to initiate the circuits which follow.

c. Manual Operation

The Type 404 Pulse Generator can be driven manually at a repetition rate determined solely by the operator. Depressing the MANUAL push button provides a single pulse of selected width and amplitude. From this point on, the instrument is driven through the pulse-generating cycle as explained elsewhere.

3-3. TIMING AND PULSE GENERATOR

a. Pulse Delay Circuit

The purpose of the pulse delay circuit is to produce a trigger which occurs 2 to approximately 125 microseconds after time t_0. This enables the start of the OUTPUT PULSE to be advanced up to 2 microseconds or delayed up to 125 microseconds with respect to the delayed OUTPUT trigger in three overlapping ranges.

Waveform **B,** occurring at time t_0 is coupled through a series triggering diode (V103B) to the variable trigger position multivibrator (V201) which generates waveforms **H** and **I.** Actually this is the pulse delay circuit; the duration of this delay is adjustable by use of the TRIGGER RANGE and VERNIER controls. Waveform **I** is differentiated by C205 and R209 which yields waveform **J.**

The trigger position buffer amplifier (V202) amplifies only the positive portion of waveform **J.** The amplified output is an isolated low-impedance negative trigger source for subsequent stages.

b. Pulse Turn-On Circuit

Waveform **K** at the plate of V202 is used to simultaneously initiate the residual pulse-on multivibrator (V203) and the pulse width delay multivibrator (V207).

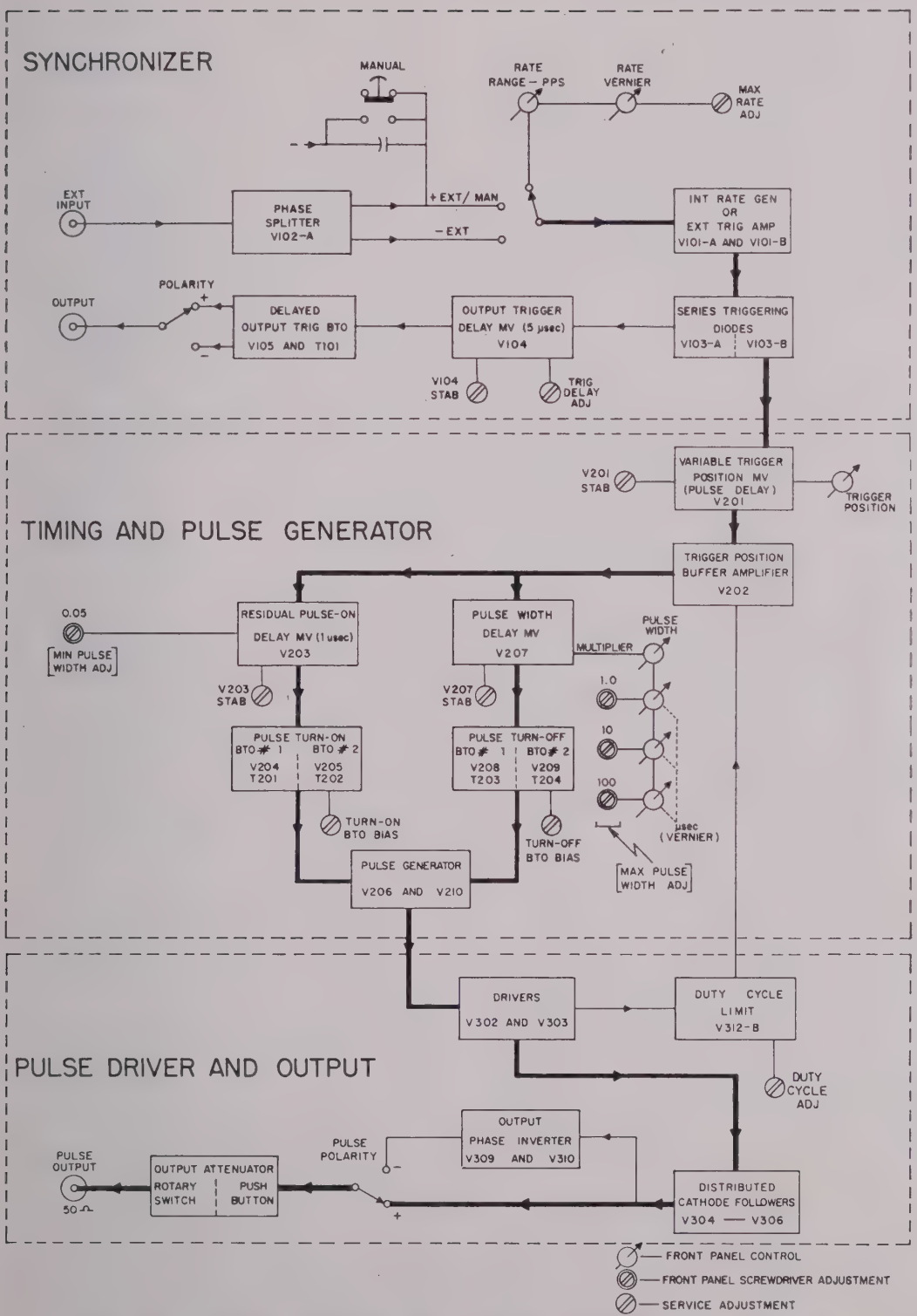


Figure 3-1. Over-all Functional Block Diagram, Du Mont Type 404/404-R Pulse Generator

section 3
theory of operation

The residual pulse-on delay circuit was inserted to simplify setting the minimum pulse width to 0.05 microseconds. V203 generates waveforms **L** and **M** and the latter waveform is differentiated by C209 and R219 to obtain waveform **N.** The positive portion of waveform **N** is used to fire the pulse turn-on BTO #1 (V204 & T201), which in turn fires BTO #2 (V205 & T202). The purpose of the cascaded blocking oscillator stages is to create a very sharp, narrow trigger with which to turn on the normally nonconducting tube (V206) of the pulse generator. See waveform **O** through **T** inclusively.

c. Pulse Turn-Off Circuit

Some time after the pulse generator is turned on, the output from a similar pair of cascaded blocking oscillators (pulse turnoff BTO #1: V208 & T203; BTO #2: V209 & T204) is used to turn off the main pulse. The time of the turn off is determined by the trailing edge of the pulse width delay multivibrator (V207), whose duration is controlled from the front panel by the PULSE WIDTH MULTIPLIER and μSEC controls. See waveforms **J** through **Y** inclusively.

At this point, the action of the timing and initial pulse generation phases is complete with the net result consisting of a negative pulse with fast transitions, controllable duration and position. From this point on, the function of the remaining circuitry is to process the initial pulse by speeding up, clipping and impedance transformation.

3-4. PULSE DRIVER AND OUTPUT

a. Driver

The driver stage (V302 & V303) consists of a pair of power pentodes with the control grids clamped to zero bias. The screen grid voltage of this stage is derived from V301 and adjusted by R302 so the plates of V302 and V303 are drawing maximum allowable current.

When the negative pulse from the pulse generator (V206 & V210) appears at the control grids of V302 and V303, plate current is abruptly cut off resulting in a large positive pulse at the plates. See waveform **Z.**

The driver plate load consists of the input end of a lumped constant transmission line terminated in its characteristic impedance of 300 ohms. The line serves a dual function of 1) separating the input capacitance of the output stage from the driver plates, thereby preserving pulse rise time and 2) making possible the use of three low-cost tubes in parallel for the output stage.

b. Distributed Cathode Followers (see Figure 3-3)

Each of the grids of the distributed cathode followers (V304 to V306) is connected to a different point on the delay line, in sequence, and uniformly spaced, so that the signal at each grid arrives at a time slightly later than that of its predecessor. Correction for this time difference is made by lengths of coaxial cable. Operation of the circuit is as follows: Since the first tube (V304) on the delay line receives the signal first, it has the longest delay correction in its cathode. The second tube, V305, has only one-half the delay correction of V304, whereas V306 has no correction. Thus, when the three outputs meet at a common point, all three signals combine and are additive.

The parameters of each of the distributed cathode followers are adjusted for an average source impedance of 150 ohms so that the three cathodes in parallel result in the universally accepted 50-ohm source impedance.

Additional refinements for the preservation of pulse waveform are incorporated such as the limit resistor (R315, R318, & R323) in each distributed cathode-follower grid which enables a clipping action thereby serving to maintain a uniformly flat pulse top. Also, each screen grid is made to follow the cathode waveform by means of screen-to-cathode bypass capacitors (C306 to C308). By holding screen voltages constant with respect to the input signal, the Miller capacity is held to a minimum which further serves to reduce increases in rise time due to capacitive loading.

c. Output Phase Inverter

Provision for negative output pulses is made via an output phase inverter (V309 & V310) stage consisting of a pair of high perveance dual triodes in parallel, driven from the distributed cathode followers. Part of the phase inverter plate load consists of a pair of ordinary 6.3-volt pilot light bulbs (DS301 and DS303) which serve as non-linear plate loads. Their function is to provide an increase in plate load as average current increases at high repetition rates, thereby serving to maintain constant amplitude negative pulses. Since the phase inverter grids are driven hard into conduction, changes of bias would result due to charging of the input coupling capacitor (C316). This is prevented by means of the phase inverter bias regulator (V311 & V312A) whose function is to maintain a constant, regulated bias source for V309 and V310.

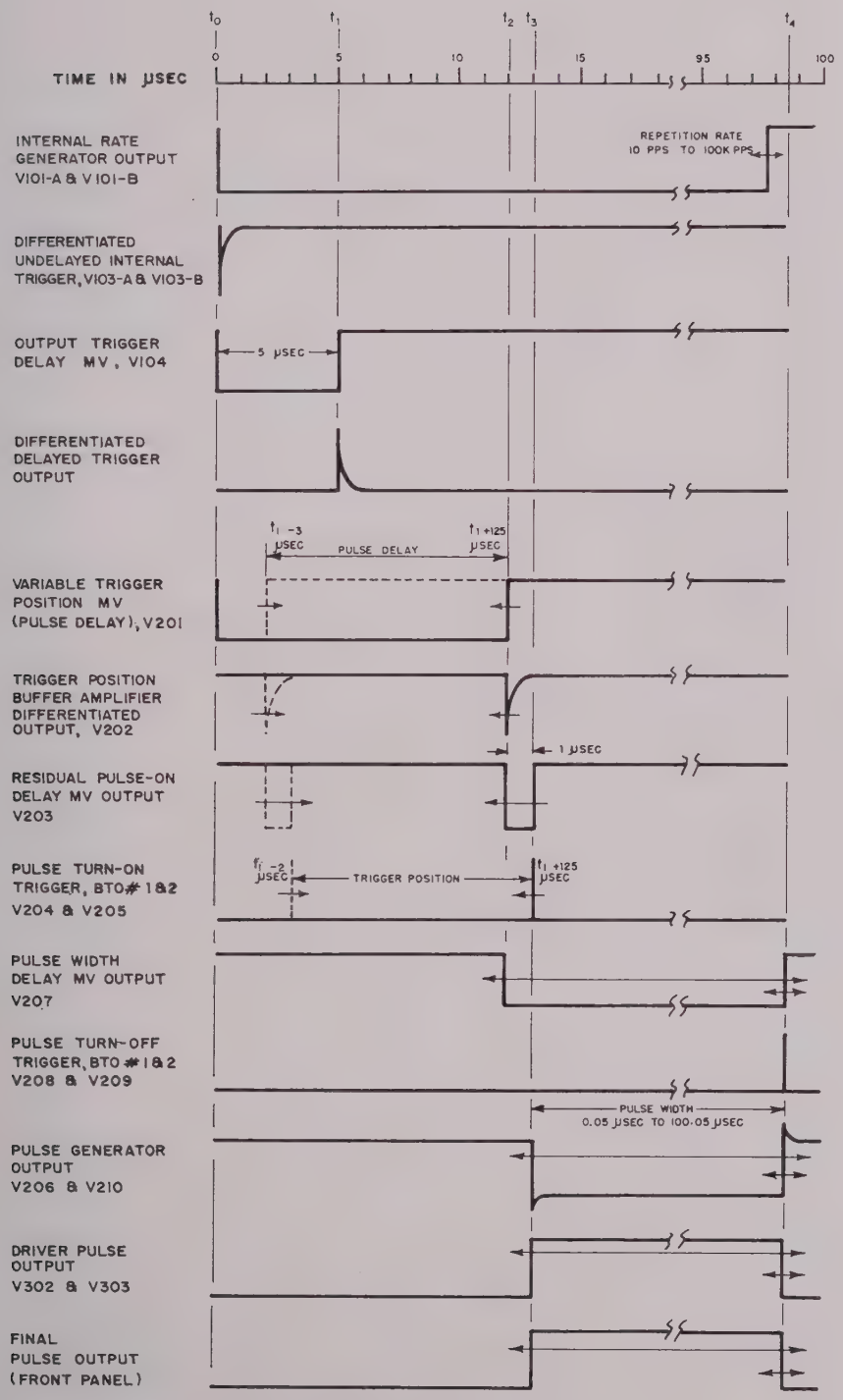

TIME IN μSEC
INTERNAL RATE GENERATOR OUTPUT V101-A & V101-B
REPETITION RATE 10 PPS TO 100K PPS
DIFFERENTIATED UNDELAYED INTERNAL TRIGGER, V103-A & V103-B
OUTPUT TRIGGER DELAY MV, V104
5 μSEC
DIFFERENTIATED DELAYED TRIGGER OUTPUT
PULSE DELAY
VARIABLE TRIGGER POSITION MV (PULSE DELAY), V201
TRIGGER POSITION BUFFER AMPLIFIER DIFFERENTIATED OUTPUT, V202
1 μSEC
RESIDUAL PULSE-ON DELAY MV OUTPUT V203
TRIGGER POSITION
PULSE TURN-ON TRIGGER, BTO # 1&2 V204 & V205
PULSE WIDTH DELAY MV OUTPUT V207
PULSE TURN-OFF TRIGGER, BTO # 1&2 V208 & V209
PULSE WIDTH 0.05 μSEC TO 100.05 μSEC
PULSE GENERATOR OUTPUT V206 & V210
DRIVER PULSE OUTPUT V302 & V303
FINAL PULSE OUTPUT (FRONT PANEL)

Figure 3-2. Type 404/404-R Pulse Generator Simplified Timing Diagram

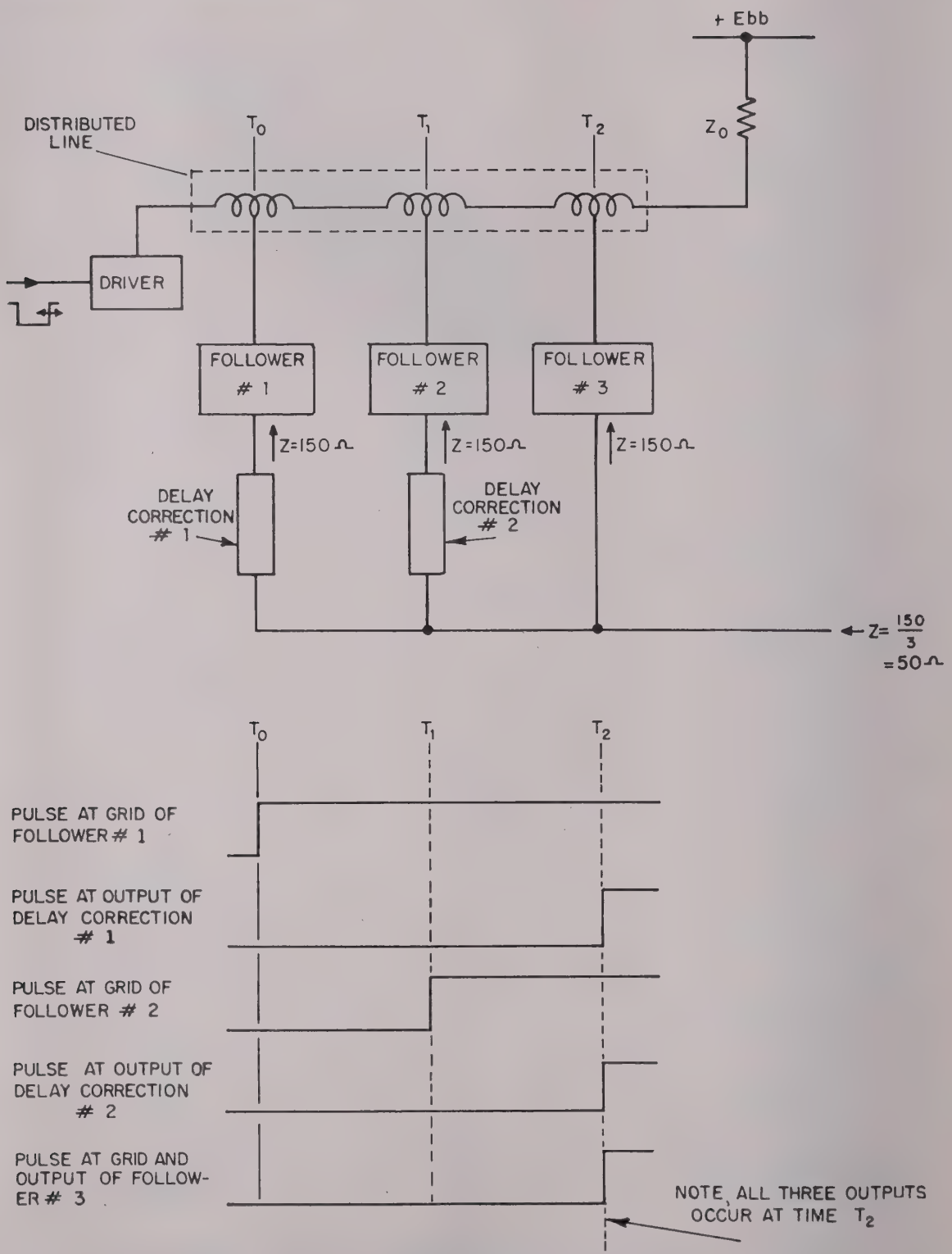


Figure 3-3. Distributed Cathode Followers, Simplified Schematic

d. Duty Cycle Limit

Some circuits in the Type 404 Pulse Generator operate with very high peak currents in the vicinity of two amperes. Consequently, it becomes necessary to limit the duty cycle to a point where the average power dissipation does not exceed safe tube and component rating. A positive safety feature has been incorporated to prevent operation beyond these ratings. This consists of an integrator circuit (C301 & R311) which compares pulse width to repetition rate. When the duty cycle reaches 10%, a relay (K301) is actuated which applies a negative voltage through the DUTY LIMIT indicator, DS305, to the grid of the trigger position buffer amplifier, V202. This action intermittently turns V202 off and on. The operator is made physically aware of the danger point by a warning light flash on the front panel (DUTY LIMIT). As soon as the pulses stop, the relay lets go allowing operation to resume. If nothing is done to lower the duty cycle, such as reducing pulse width or repetition rate, this process will continue at a rate determined by the amount that the duty cycle is being exceeded. In this way, the average power dissipation is automatically reduced to a safe value.

3-5. ATTENUATOR

A series of five 10 db attenuator steps are arranged in a ladder configuration so that only the first step requires high-wattage resistors; all of the other resistors used are standard one-half watt value. Six additional push button actuated attenuators provide sufficient small increments to enable a total attenuation range of 59.5 db in 0.5 db steps. The major advantage of this system is that a true impedance match exists under any possible combination of attenuator settings, thereby minimizing distortion of pulse waveforms.

3-6. POWER SUPPLY

a. +250 Supply Voltage

The +250-volt supply uses two selenium rectifiers (CR501 & CR502) connected in a conventional voltage doubling circuit. Capacitors C501 and C502 are charged on alternate half cycles and are connected in series, thus yielding an output voltage that is twice the peak voltage of the ac supply (about 100 volts). This voltage is added to the output from the +130-volt rectifier making a total of approximately 300 volts, which is then applied to a conventional voltage regulator yielding +250 volts output.

b. +130 Supply Voltage

The +130-volt supply uses two selenium rectifiers (CR503 & CR504) connected in a conventional full-wave rectifier circuit. The rectified output is capacitively filtered (C505 to C507) and is applied to a conventional voltage regulator which yields +130 volts output.

c. Negative 150 Supply Voltage

The negative 150-volt supply uses two selenium rectifiers (CR505 & CR506) connected as a voltage doubler. This circuit produces a result equivalent to that of a conventional voltage-doubling circuit except that it has the advantage of a high-source impedance. The rectified output is regulated by a gas diode (V506).

The instrument is protected by a 6¼ ampere fuse, (F501) located in the primary circuit.

SECTION 4
MAINTENANCE

4-1. GENERAL

The Type 404 Pulse Generator is enclosed in a cabinet which is composed of two removable covers (top and bottom). To gain access to the chassis, loosen the screws on top and sides of the desired cover and slip it out of the slotted holes. To gain access to the Type 404-R chassis, remove the dust cover.

WARNING

OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED:

1) Never work alone.
2) Make sure the chassis is properly grounded.
3) Remove power cord before changing any tubes.
4) Before touching any components, short the terminals to remove any possible charge that may remain after turning off the power.

4-2. SERVICE ADJUSTMENTS AND INITIAL TROUBLE-SHOOTING PROCEDURE

a. General

The adjustment procedure given in the following paragraphs is based on the assumption that: (1) the instrument had been working satisfactorily and has become defective due to aging and/or drift of critical tubes and components; or (2) has had tube and/or component failure, has been serviced, and therefore needs readjustment.

The information given below may also be used for initial trouble shooting when it is desired to localize a point failure. Localizing the trouble is made easier by use of a test probe coupled to a cathode-ray oscilloscope. The correct waveforms are shown on the schematics. Each waveform is identified by a code letter to show the exact point at which it occurs.

b. Test Equipment Required (Table 4-1)

c. Preliminary Settings (Table 4-2)

Set all front-panel controls and service adjustments as indicated in the "Initial Setting" column of Table 4-2.

The adjustment procedure has been broken down into a step-by-step arrangement and should, if carefully followed, result in satisfactory performance.

d. Supply Voltages

NOTE

Allow 10 minutes for warmup before making any adjustments.

A warmup time of at least ten minutes is mandatory before making any of the adjustments given in this and later paragraphs. This warmup period insures that all critical points have settled down reasonably close to their final value. Any new tube installation may require that surrounding adjustments be reset after several hours of initial aging.

Check and reset, if necessary, all supply voltages to greatest possible degree of precision. Test points and proper sequence are as follows (see page 14):

TABLE 4-1
EQUIPMENT REQUIRED FOR ADJUSTMENTS AND TROUBLE SHOOTING

DESCRIPTION	CHARACTERISTICS
Volt-ohmmeter	20,000 ohms/volt sensitivity; calibrated to highest feasible accuracy
Cathode-ray Oscilloscope	Du Mont Type 329-A Cathode-ray Oscilloscope or equivalent; supplied with appropriate low-capacity probes
Coaxial Cables	Two; four to six-foot lengths of 50-ohm coaxial cables supplied with BNC plugs at either end. Provision should be made for terminating the output ends with 50-ohm resistors, preferably through the use of a coaxial "Tee's" and plugged-on terminations. In addition, one of the cables should be prepared to enable viewing of the pulses directly to the cathode-ray tube deflection plates (see Figure 2-1)

TABLE 4-2
INITIAL ADJUSTMENT SETUP

NAME AND LOCATION	REFERENCE SYMBOL	FUNCTION	INITIAL SETTING
(TRIGGER) POSITION VERNIER Front Panel	R201A, B	Permits continuous adjustment of the start of the OUTPUT PULSE with respect to the trigger OUTPUT signal	Fully CW
(TRIGGER) POSITION RANGE μSEC Front Panel	S202	Provides three overlapping ranges for adjusting the start of the OUTPUT PULSE	Fully CCW
(TRIGGER) RATE RANGE—PPS Front Panel	S102	Selects internally generated triggers in decade steps or sets up instrument for amplifying external signals	10K-100K
(TRIGGER) POLARITY Front Panel	S103	Switches the fixed delayed trigger OUTPUT either positive or negative	Optional
(TRIGGER) RATE VERNIER Front Panel	R109A, B	Provides continuous variation of the internal repetition rate	Fully CW
PULSE WIDTH MULTIPLIER Front Panel	S201	Multiplies the μSEC dial setting by factors of ten	X0.1
0.05 μSEC Pulse Width Front Panel	R214	Controls width of residual pulse delay for calibration of 0.05 pulse	Fully CCW
1.0 μSEC Max Adj Front Panel	R242	Calibrates high end of 1 μsec pulse range	Fully CW
10 μSEC Max Adj Front Panel	R237	Calibrates high end of 10 μsec pulse range	Fully CW
100 μSEC Max Adj Front Panel	R232A, B	Calibrates high end of 100 μsec pulse range	Fully CW
(PULSE WIDTH) μSEC Front Panel	R234A, B, C	Provides continuous variation of pulse width	Fully CW
ATTENUATOR (Rotary switch) Front Panel	S407	Provides 10 db step reduction of pulse amplitude up to 50 db	O db
ATTENUATOR (Push buttons) Front Panel	S401 thru S406	Used in conjunction with the rotary attenuator to enable reduction of pulse amplitude in small increments	All out (O db)
PULSE POLARITY Front Panel	S301	Switches PULSE OUTPUT either positive or negative	+ (plus)
MAX RATE ADJ Fig. 4-3	R108	Sets the maximum internal trigger repetition rate to 100,000 pps	Fully CCW
V104 STAB Fig. 4-3	R117	Controls threshold bias of V104	Fully CCW
TRIG DELAY ADJ Fig. 4-3	R120	Enables setting of pulse advance to exactly 2 microseconds	Fully CW
V201 STAB Fig. 4-3	R206	Controls threshold bias of V201	Fully CCW
V203 STAB Fig. 4-3	R212	Controls threshold bias of V203	Fully CCW
V207 STAB Fig. 4-3	R243	Controls threshold bias of V207	Fully CCW
1 μSEC Pulse Width Fig. 4-2	C207	Enables setting of V203 pulse width to exactly 1 microsecond	Optional

TABLE 4-2 INITIAL ADJUSTMENT SETUP (Continued)

NAME AND LOCATION	REFERENCE SYMBOL	FUNCTION	INITIAL SETTING
Pulse Width Cal Adj Fig. 4-3	C223	Calibrates low end of X0.1 pulse range	Midpoint
Pulse Width Cal Adj Fig. 4-3	C221	Calibrates low end of X1.0 pulse range	Midpoint
Pulse Width Cal Adj Fig. 4-3	C218 & C219	Calibrates low end of X100 pulse range	Midpoint
TURN-ON BTO BIAS Fig. 4-3	R257	Hold-off bias for V205	Fully CW
TURN-OFF BTO BIAS Fig. 4-3	R258	Hold-off bias for V209	Fully CW
—7.5V ADJ Fig. 4-2	R261	Sets output of cathode-follower regulator to —7.5 volts	Fully CW (As seen from bottom of chassis)
DRIVER SCREEN ADJ Fig. 4-3	R302	Controls pulse baseline via V302 and V303 screen voltage	Midpoint
DUTY CYCLE ADJ Fig. 4-4	R309	Sets the maximum duty cycle of the instrument to 10%	Fully CW
INVERTER BIAS Fig. 4-4	R343	Controls the shape of the negative pulse	Fully CCW
Delay Line Adjustments Fig. 4-3	L301, L302, C304, C313	Controls the shape of the positive pulse	Optional
Attenuator Trimmer Fig. 4-4	C401	Used to preserve pulse waveshape	Optional
+250V ADJ Fig. 4-1	R515	Sets output of +250-volt regulator	Fully CCW
+130V ADJ Fig. 4-1	R532	Sets output of +130-volt regulator	Fully CCW

d. Supply Voltages (Continued from Page 12)

Step	Supply Voltage	Test Point
1.	—150 volts	Connect a voltmeter from pin 4 of V506 (negative) and ground. Voltage should measure between —145 and —155 volts.
2.	+130 volts	Connect a voltmeter from the test point indicated in Figure 4-3 and ground. Adjust R532 for +130 volts.
3.	+250 volts	Connect a voltmeter from the test point indicated in Figure 4-3 and ground. Adjust R515 for +250 volts.
4.	—7.5 volts	Connect a voltmeter from pin 8 of V102 (negative) and ground. Adjust R201 —7.5 volts (equipment untriggered).

e. Internal Rate Generator, V101

1) Check waveform **B** in all positions of (TRIGGER) RATE RANGE and RATE VERNIER controls (except external positions).
2) Set (TRIGGER) RATE RANGE to 10K-100K, RATE VERNIER fully clockwise, and POLARITY to plus.
3) Adjust MAX RATE ADJ, R108, to give precisely 100,000 pps (pulse interval equals 10 microseconds.)
4) When internal rate generator performance has been found satisfactory, set panel controls for about 7000 pps to facilitate adjustment of the next stage.

f. Output Trigger Delay MV, V104

At this point, some detailed discussion on how to adjust the stability of a cathode-coupled multivibra-

(Continued on page 19)

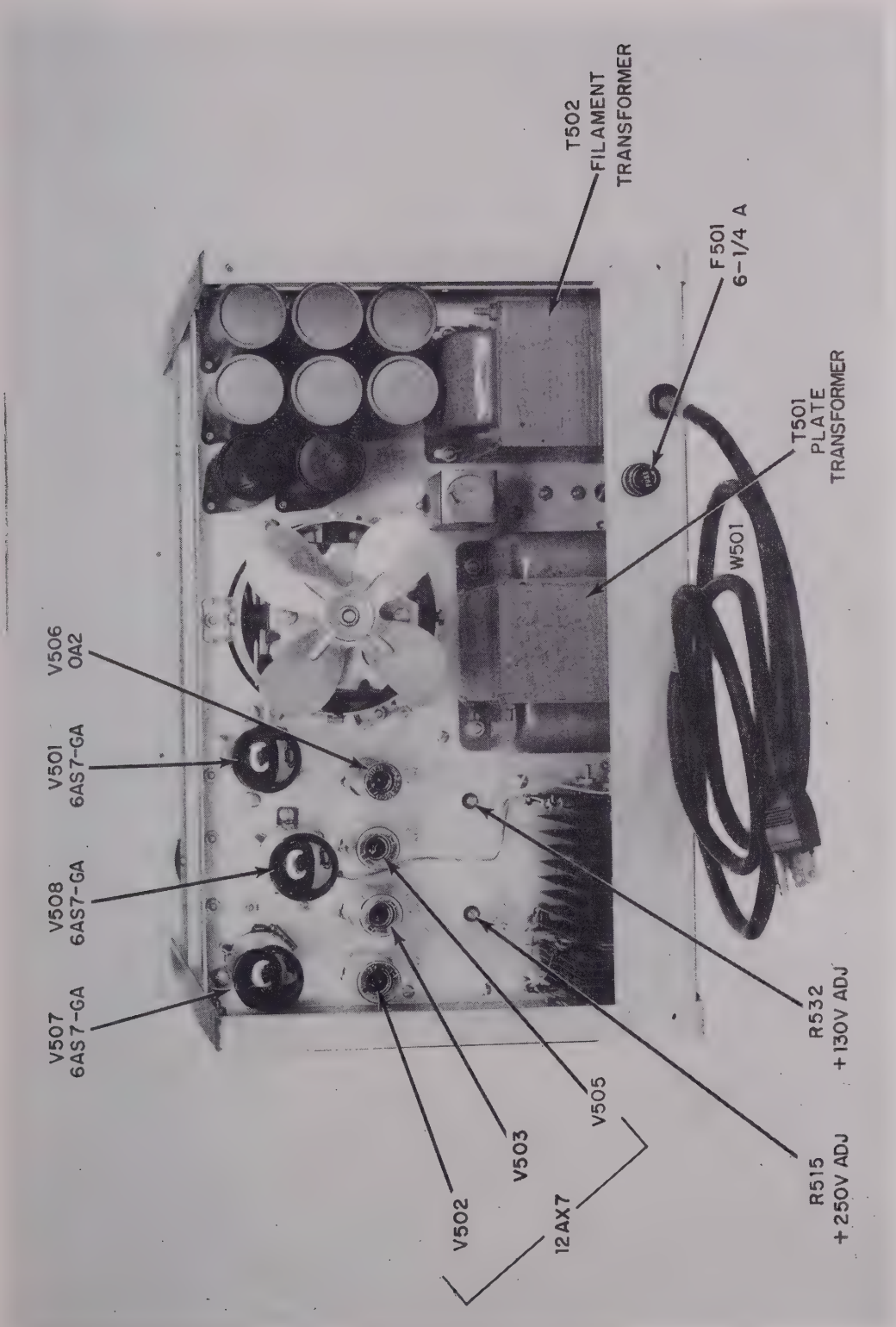


Figure 4-1. Tubes and Adjustments, Rear View

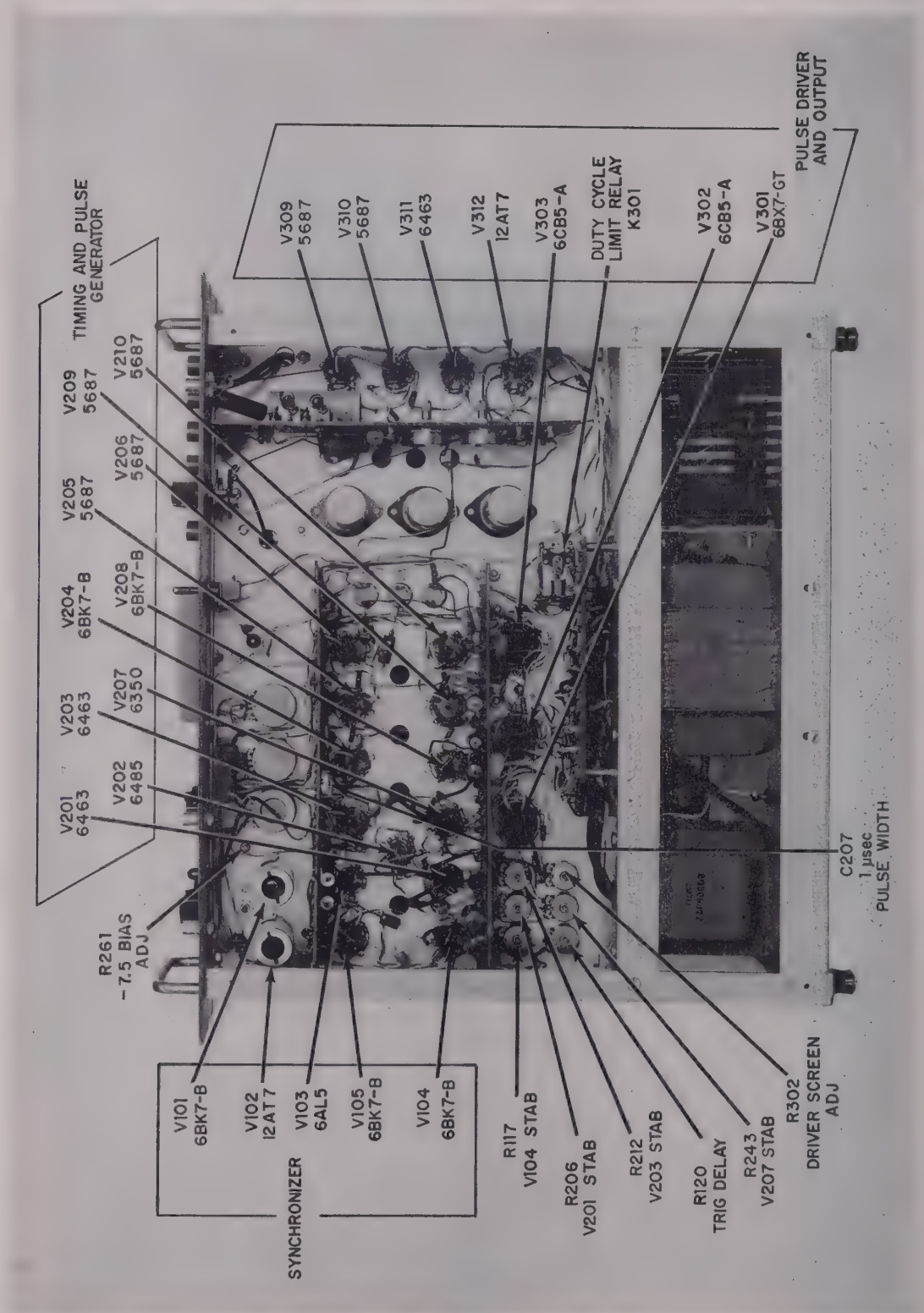


Figure 4-2. Tubes and Adjustments, Bottom View

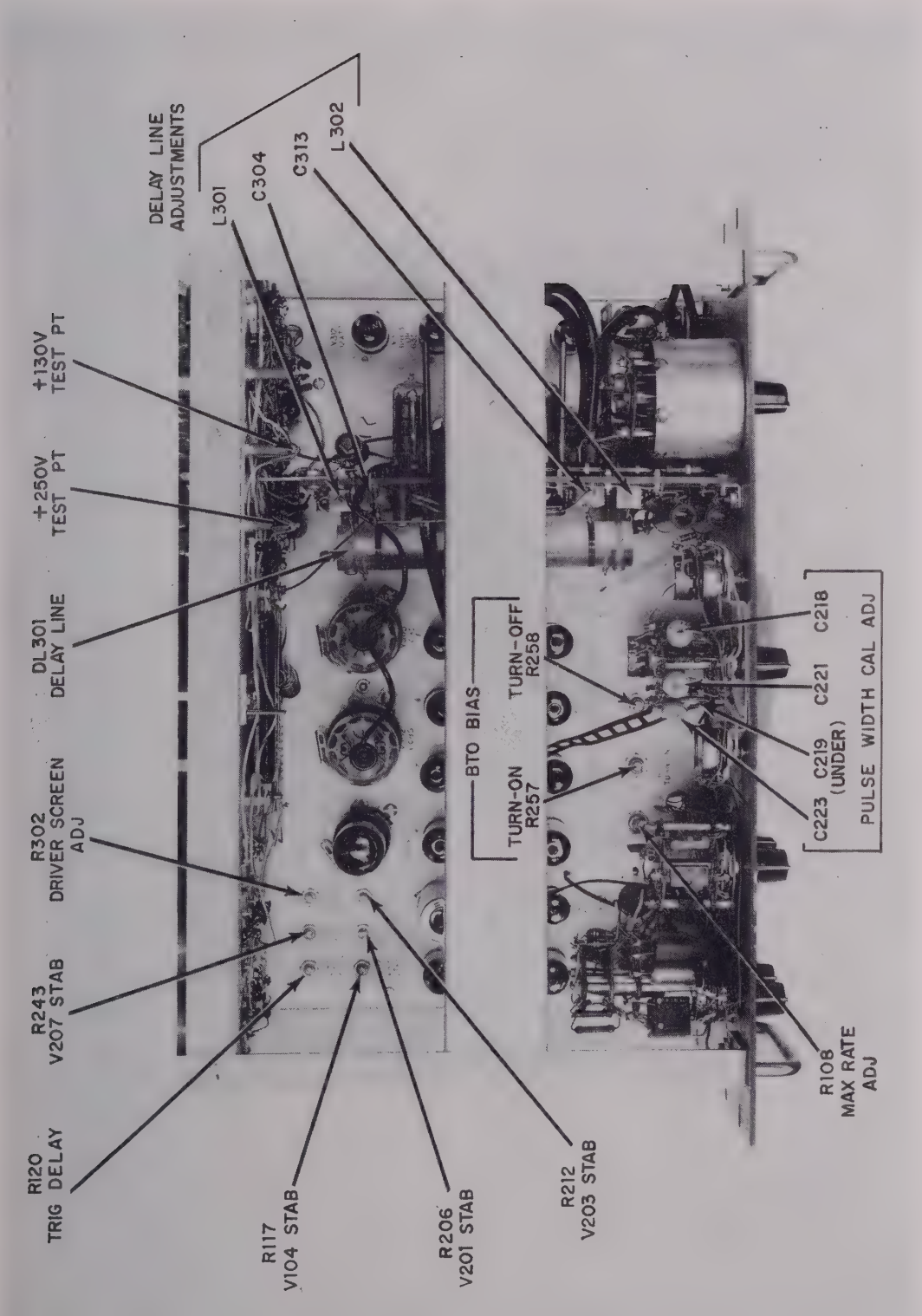


Figure 4-3. Adjustments, Top View

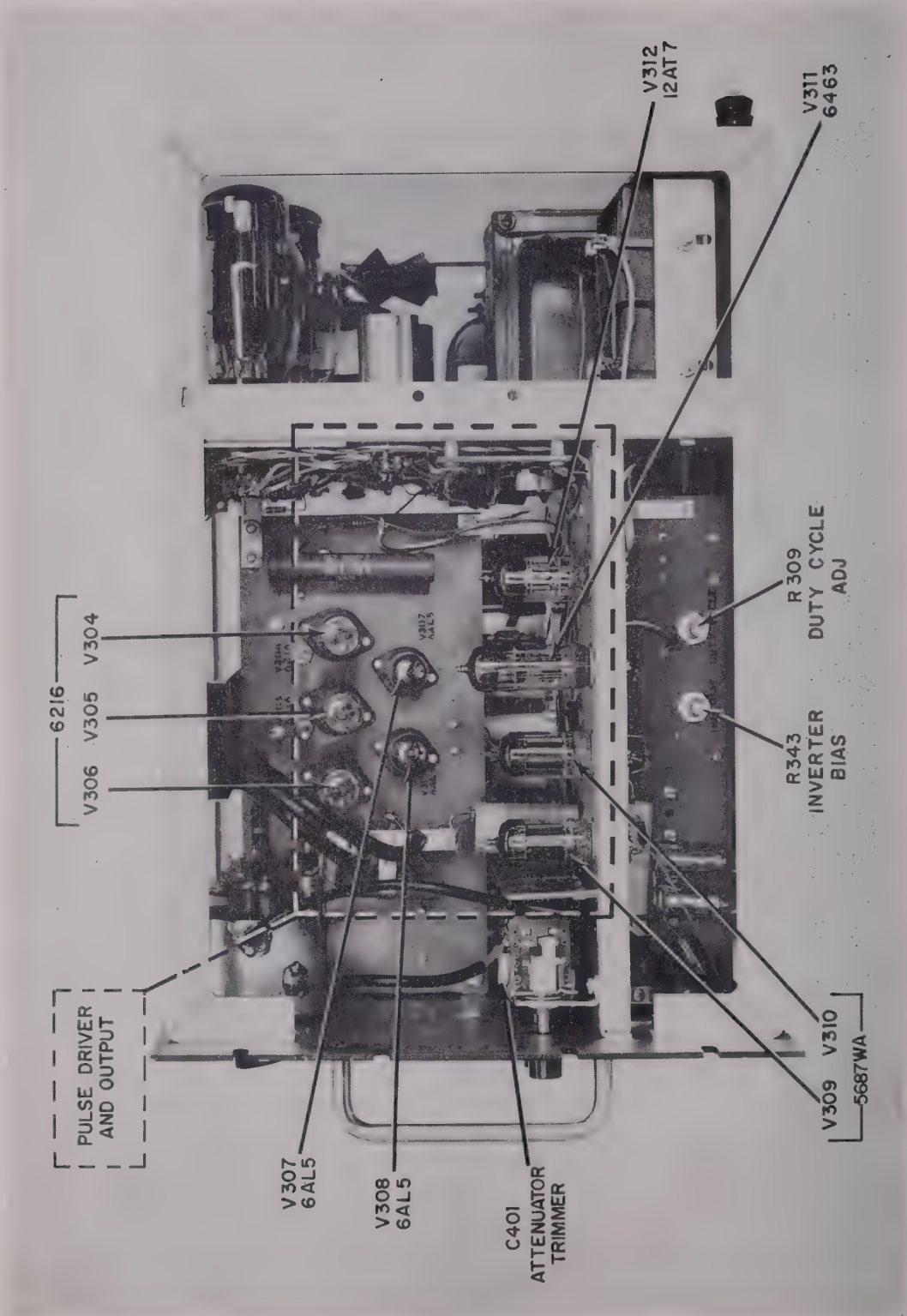


Figure 4-4. Tubes and Adjustments, Right Side

tor may be in order. A quick analysis of V104 circuitry shows that the cathode voltage across R122 depends on the plate current through the normally conducting triode. This plate current in turn depends on the setting of TRIG DELAY ADJ, R120, such that the cathode voltage will be lowest when R120 is set to its maximum resistance value and vice versa.

For optimum sensitivity, this type of multivibrator requires that the voltage at the grid (pin 2) of the normally cutoff triode be held slightly below the cathode voltage to maintain this condition. If the stability adjustment were made with the cathode voltage at its maximum value, then an increase in grid resistance or a change in tube characteristic due to age, would cause a drop in cathode voltage such that the normally cutoff triode would start conducting. This would result in an unstable mode of operation approaching a free-running condition. Therefore, it is necessary to adjust the stability control with the cathode voltage at its minimum value (grid resistance maximum or with TRIG DELAY ADJ set fully CW).

1) Examine waveform **D** while turning V104 STAB, R117, clockwise to a point where instability is noted.
2) When this point is reached, set R117 slightly below the point of instability and note width of waveform **D**; then, back off (counterclockwise) until width of waveform **D** reduces by 10%. This backing-off procedure is done to allow for future tube and component aging.

g. Delayed Output Trigger BTO, V105

Check waveforms **F** and **G** across (TRIGGER) RATE RANGE controls. The amplitude of waveform **G** may vary between 20 and 50 volts depending on tube parameters and is not critical. From this point on, the synchronizer portion of the circuitry may be assumed to be operating properly and the delayed trigger OUTPUT may be used for sweep initiation of the cathode-ray oscilloscope when necessary.

h. Variable Trigger Position MV, V201

1) Check waveform **I** using negative internal sync on the oscilloscope.
2) Examine waveform **I** while turning V201 STAB, R206, clockwise to a point where instability is noted.
3) When this point is reached, set R206 slightly below the point of instability and note width of waveform **I**; then, back off (counterclockwise) until width of waveform **I** reduces by 10%. This backing-off procedure is done to allow for future tube and component aging.
4) Vary (TRIGGER) POSITION VERNIER and POSITION RANGE μSEC controls across their range and note that waveform **I** remains stable.
5) Repeat step 4 except that waveform **J** is checked.

i. Trigger Position Buffer Amplifier, V202

1) Check waveform **K** using negative internal sync on the cathode-ray oscilloscope.
2) Vary (TRIGGER) POSITION VERNIER and POSITION RANGE μSEC controls across their range and note that waveform **K** remains essentially constant.

j. Residual Pulse-on Delay MV, V203

1) Set 0.05 μSec Pulse Width control fully counterclockwise. Examine waveform **M** while turning V203 STAB, R212, clockwise to a point where instability is noted.
2) When this point is reached, set R212 slightly below the point of instability and note width of waveform **M**; then, back off (counterclockwise) until width of waveform **M** reduces by 10%. This backing-off procedure is done to allow for future tube and component aging.
3) Adjust C207 such that the width of pulse **M** is precisely one microsecond.
4) Check that waveform **M** remains precisely one microsecond wide and stable across the repetition rate range. If at this point the duty cycle relay starts to clatter, this is an indication that the initial pulse generator, V206 and V210, is being triggered. Since the turn-off loop has not yet been set up, the initial pulse has its full possible duration of about 150 microseconds and requires that the repetition rate be reduced to about 6000 pps.

k. Pulse Turn-on BTO #1, V204

Check waveform **O**. No adjustment is required. This positive output pulse should be coincident with the trailing edge of waveform **M** or **N**.

m. Pulse Turn-on BTO #2, V205

Check waveform **P**. This waveform should remain nearly constant for all settings of the (TRIGGER) POSITION, VERNIER POSITION RANGE μSEC, and RATE RANGE controls. (Amplitude varies slightly with TURN-ON BTO BIAS, R257.)

n. Initial Pulse Generator, V206 and V210

1) Check waveform **S**.
2) If no pulse appears, rotate TURN-ON BTO BIAS, R257, counterclockwise until the proper waveform appears.

3) Occasionally, it might be necessary to adjust the TURN-OFF BTO BIAS, R258, since there might be a small degree of interaction. The effect of R258 is such that it might prevent the initial pulse from reaching its full duration. If this happens, rotate R258 clockwise to the point where it no longer affects waveform **S**.

p. Pulse Width Delay MV, V207

1) Set PULSE WIDTH MULTIPLIER to X10 and μSEC dial fully clockwise.
2) Examine waveform **V** while turning V207 STAB, R243, clockwise to a point where instability is noted.
3) When this point is reached, set R207 slightly below the point of instability and note width of waveform **V;** then, back off (counterclockwise) until width of waveform **V** reduces by 10%. This backing-off procedure is done to allow for future tube and component aging.
4) Vary PULSE WIDTH MULTIPLIER and μSEC controls across their range and note that waveform **V** remains essentially constant.
5) Repeat step 4 except that waveform **W** is checked.

NOTE: If for any reason it is desired to make tests or adjustments of the turn-off circuitry at higher repetition rates, remove V204. This is necessary because the initial pulse at this point in the procedure might be operating at its maximum width and would, therefore, exceed the safe duty limit at repetition rates above 6000 pps.

q. Pulse Turn-off BTO #1, V208

Check waveform **X.** No adjustment is required. The positive portion of this waveform should be coincident with the trailing edge of waveform **V** or **W.** Waveform **X** should be nearly constant for all settings of PULSE WIDTH and (TRIGGER) RATE RANGE controls.

r. Pulse Turn-off BTO #2, V209

1) Check waveform **Y.**
2) This waveform should be essentially constant for all settings of PULSE WIDTH and (TRIGGER) RATE RANGE controls.
3) Assuming that the pulse driver and output portion of the system is in operation, the final pulse waveform can be viewed directly on the deflection plates of the oscilloscope using a properly terminated cable (see Table 4-1). Some trimming of the TURN-ON and TURN-OFF BTO BIAS adjustments might be necessary to achieve optimum performance.
4) Set the pulse width to approximately ½ microsecond and, if necessary, adjust TURN-ON BTO BIAS to correct the leading edge of the pulse as the repetition rate is increased to 100,000 pps.
5) Using a repetition rate of about 5000 pps, adjust TURN-OFF BTO BIAS to the point where it has no effect on the maximum pulse width.

s. Pulse Waveshape, Driver Screen Regulator, V301

1) Due to the many variables involved, no specific method for adjusting the delay-line compensators, C304, L301, C313, and L302 can be recommended. Therefore, adjust these compensators for the best possible pulse waveshape.
2) Provision has been made for further adjustment of delay-line termination (not normally required) by means of adding or removing jumpers across R326 through R329.

NOTE: Any change in delay-line termination should be accompanied by readjustment of C304, L301, C313, and L302.

3) If the pulse leading edge deteriorates at maximum repetition rate, adjust TURN-ON BTO BIAS.
4) Similarly, if the pulse trailing edge is erratic as the repetition rate is increased, adjust TURN-OFF BTO BIAS. In any event, both TURN-ON and TURN-OFF BTO BIAS's should be set as near clockwise as possible (highest possible bias).
5) It may be necessary to go back and forth several times, resetting each of the above adjustments until the best possible compromise in waveshape is reached. If a satisfactory pulse waveshape cannot be achieved, then selection of the distributed cathode-follower tubes, V304 through V306, may result in some improvement.

t. Negative Pulse, Phase Inverter Bias Regulator, V311 and V312A

1) Set PULSE POLARITY to minus.
2) Adjust INVERTER BIAS, R343, for the best possible negative pulse.
3) Adjust Attenuator Trimmer, C401 for sharpness at the beginning of the pulse flat top and with minimum possible ringing or overshoot. Recheck for possible effect on positive pulse.

u. Duty Cycle Limit, V312B

1) Set (TRIGGER) RATE RANGE to 10K-100K and POSITION VERNIER fully clockwise.

2) Set PULSE WIDTH MULTIPLIER and μSEC dial for a one microsecond pulse.
3) Starting from the fully clockwise position, set DUTY CYCLE ADJ, R309, to the point where the duty cycle limit relay, K301, begins to click and the DUTY LIMIT indicator flashes.
4) Increasing the pulse width should increase relay clicking; decreasing the pulse width to less than one microsecond should cause the relay to stop clicking.

v. Adjusting Trigger Position Range

1) Connect properly terminated cables between trigger OUTPUT and the external sync terminal of a cathode-ray oscilloscope; and between PULSE OUTPUT and vertical input of the oscilloscope.
2) Set PULSE WIDTH MULTIPLIER and μSEC controls for a 2 microsecond pulse.
3) Set (TRIGGER) POSITION VERNIER fully counterclockwise and POSITION RANGE to 5.
4) Adjust TRIG DELAY ADJ, R210, so that the trailing edge of the pulse is just barely visible at left edge of screen.
5) Since R120 is turned counterclockwise in step 4, V104 STAB should be reset according to instructions in paragraph f.

4-3. PULSE WIDTH CALIBRATION PROCEDURE

a. Gentral

The following information should be noted before making any adjustments:

1) Due to the inherent backlash in the triple-sectioned μSEC control, R234A, B, C, always approach the required μSEC dial setting in the clockwise direction.
2) Pulse widths of 0.5 microsecond or less will exhibit a tendency to change with time and repetition rates. This is due to the nature of the circuitry in which pulse duration is determined by the difference in width between two active multivibrators. At minimum pulse widths, very small changes in these multivibrators produce relatively large changes in pulse width. For these reasons, calibration of narrow pulses is not precise.
3) As the output pulse is made narrower (approaching 0.03 μsec), a point is reached where the pulse turn-off trigger coincides with and supersedes the effect of the turn-on trigger. When this happens, the turn-off trigger becomes a turn-on trigger with the result that the initial pulse is turned on and stays on for its entire duration of approximately 150 microseconds. Thus, at repetition rates greater than about 6000 pps, the DUTY CYCLE indicator will begin flashing. When this occurs, it should be obvious to the operator that the panel controls are being set for too narrow a pulse.

b. Adjustment Procedure

1) Set μSEC dial to 1, PULSE WIDTH MULTIPLIER to X0.1, and turn the 0.05 μSec Pulse Width panel control to center of range.
2) Adjust C223 to obtain a pulse width of 0.1 microsecond as viewed on a cathode-ray oscilloscope. Check to see that the 0.05 μSec Pulse Width control enables the pulse width to be reduced to 0.05 microsecond, then reset it to 0.1 microsecond.
3) Switch PULSE WIDTH MULTIPLIER to X1 and adjust C221 to obtain a pulse width of exactly 1 microsecond. If necessary, the μSEC dial may be slipped slightly counterclockwise on its shaft in order to achieve the desired result. If the μSEC dial is slipped to a new position, it will be necessary to repeat steps 1 and 2.
4) Switch PULSE WIDTH MULTIPLIER to X10 and adjust C218 and/or C219 to obtain a pulse width of exactly 10 microseconds.

   NOTE: The following procedure is required *only* when R235 is replaced or if its original value has changed excessively. To facilitate the adjustment procedure described in step 4, the value of R235 may be changed from 360K to 300K, 200K or 150K by shunting it with resistance values of 1.8M, 450K, or 760K respectively.

5) Turn μSEC dial to 10 and set the 100 μSec Max Adj panel control to obtain a pulse width of 100 microseconds. Difficulty in making this adjustment would indicate that the value of R235 must be readjusted by choosing a new shunt resistor. See *note* in step 4.
6) Switch PULSE WIDTH MULTIPLIER to X1 and set the 10 μSec Max Adj panel control to obtain a pulse width of 10 microseconds.

   NOTE: The following procedure is required *only* when R234A, B, C has been replaced or if the pulse width cannot be set to 10 microseconds. To facilitate the adjustment procedure described in step 6, it may be necessary to slip the μSEC dial clockwise (superseding any

dial setting which might have been made in step 3) and install a 27 μμf capacitor in parallel with C221. Whenever the μSEC dial has been slipped to a new position, repeat all previous pulse width calibration adjustments.

7) Switch PULSE WIDTH MULTIPLIER to X0.1 and set the 1.0 μSec Max Adj panel control to obtain a pulse width of 1 microsecond.
8) After completing the above steps, tighten the μSEC dial set-screw and recheck the over-all calibration as indicated in the next steps.
9) Turn the μSEC dial to 1 and note that the pulse width is 0.1, 1, and 10 microseconds when the PULSE WIDTH MULTIPLIER is switched to X0.1, X1, and 10 positions respectively.
10) Turn the μSEC dial to 10 and note that the pulse width is 1, 10 and 100 microseconds when the PULSE WIDTH MULTIPLIER is switched to X0.1, X1, and 10 positions respectively.
11) Finally, it should be possible to obtain a 0.05 microsecond pulse when PULSE WIDTH MULTIPLIER is set to X0.1 by turning μSEC dial fully counterclockwise and/or by turning the 0.05 μSec Pulse Width control counterclockwise.

4-4. GENERAL ADJUSTMENT PROCEDURE

a. Introduction

In general, the problems involved in service and maintenance of the Type 404 Pulse Generator are the same as those found in any electronic equipment. There is no substitute for a thorough knowledge of the circuit theory. It is highly recommended that maintenance personnel study the Theory of Operation in Section 3 of this manual.

b. Adjustment Procedure

The step-by-step adjustment procedure described in paragraphs 4-2 and 4-3, was given to facilitate maintenance of the instrument by personnel who are unfamiliar with the circuitry. The following discussion is appended for use by those who are more familiar with the equipment. It describes a method for making adjustments without the need of probing into the heart of the instrument. This procedure is itemized as follows:

1) Connect a properly terminated cable between trigger OUTPUT and the external sync terminal of a cathode-ray oscilloscope; and between PULSE OUTPUT and vertical input of the oscilloscope.
2) Note that all tube heaters are lit.
3) Check all supply voltages; includes the ac power line, +250, +130, —150, and —7.5 volt levels.
4) *Do not tamper* with any of the service adjustments as this will only complicate servicing.
5) Examine the pulse on the cathode-ray tube screen for any peculiarities.
6) If the *leading* edge of the pulse appears unstable, but not the trailing edge, or if the DUTY LIMIT light is on continuously, adjust V203 STAB, R212, according to instructions in paragraph 4-2, item j.
7) If the *trailing* edge of the pulse appears jittery, but not the leading edge, adjust V207 STAB, R207, according to instructions in paragraph 4-2, item p.
8) If the *entire* pulse is jittery, this is an indication that either the output trigger delay MV, V104, or the variable trigger position MV, 201, might be unstable. In this case, either V104 STAB, R117 or V201 STAB, R206 (but not both) should be adjusted. Refer to paragraph 4-2, items f or h for adjustment instructions.
9) If the pulse deteriorates or collapses at high repetition rates, reduce the TURN-ON BTO BIAS, R257 (CCW).
10) If maximum pulse width cannot be achieved, reset TURN-OFF BTO BIAS, R258.

c. Additional Servicing Hints

1) Localizing the trouble is made easier by using a test probe coupled to an oscilloscope. Refer to the schematics for the correct waveforms.
2) Avoid short-circuiting any components with the test probe.
3) When a point is reached where normal performance ceases abruptly, a replacement tube should be tried before attempting any other tests. In some cases, a second new tube must be tried.
4) Replacement of certain tubes may require resetting of one or more service adjustments. Consult Table 4-3. For optimum stability, the new tube should be allowed a warmup time of at least one hour before making any final service adjustments.
5) If after tube replacement the trouble persists, replace the original tube in its socket and check for proper voltage and resistance per Tables 4-4 and 4-5.
6) Maintain a high quality of workmanship. Use a clean bench and soldering iron; keep solder joints smooth and bright; do not overheat any component while soldering.

TABLE 4-3
ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED
SYNCHRONIZER		
V101	6BK7-B	MAX RATE ADJ (R108)
V102	12AT7	—7.5V BIAS ADJ (R261)
V103	6AL5	None
V104	6BK7-B	V104 STAB (R117) and TRIG DELAY ADJ (R120)
V105	6BK7-B	None
TIMING AND PULSE GENERATOR		
V201	6463	V201 STAB (R206)
V202	6485	None
V203	6463	V203 STAB, (R212), 0.05 μSec Pulse Width, (R214), and 1 μSec Pulse Width (C207)
V204	6BK7-B	None
V205	5687	TURN-ON BTO BIAS (R257)
V206	5687	None
V207	6350	V207 STAB (R243); all pulse width calibration adjustments, includes: 1, 10, and 100 μsec (front panel); C218, C219, C221 and C223
V208	6BK7-B	None
V209	5687	TURN-OFF BTO BIAS (R258)
V210	5687	None
PULSE DRIVER AND OUTPUT		
V301	6BX7-GT	DRIVER SCREEN ADJ (R302)
V302 & V303	6CB5-A	Delay Line Adjustments (L301, L302, C304, and C313)
V304 to V306	6216	Delay Line Adjustments (L301, L302, C304, and C313)
V307 & V308	6AL5	None
V309 & V310	5687WA	INVERTER BIAS (R343)
V311 & V312	6463 & 12AT7	INVERTER BIAS (R343)
POWER SUPPLY		
V501	6AS7-GA	+250V ADJ (R515)
V502	12AX7	+250V ADJ (R515)
V503	12AX7	+250V ADJ (R515) and +130V ADJ (R532)
V505	12AX7	+130V ADJ (R532)
V506	OA2	None
V507 & V508	6AS7-GA	+130V ADJ (R532)

TABLE 4-4
VOLTAGE MEASUREMENTS

NOTES: 1. All voltages measured with a 20K-ohm/ voltmeter; measurements taken from tube socket to chassis
2. All voltages are dc and positive with respect to chassis, except where otherwise indicated
3. All measurements taken with RANGE RATE-PPS set to +EXT/MAN
4. *Indicates measurement with VTVM

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
					SYNCHRONIZER					
		NOTES: 5. Tube socket voltage variation is indicated as follows: a) Varies with V104 STAB (R117)								
V101	6BK7-B	50	0.5	0	0	6.3ac	128	—7	0	0
V102	12AT7	125	*4.5	5	0	0	130	—8.5	—7.5	6.3ac
V103	6AL5	130	130	0	6.3ac	130	0	130	.....	.....
V104	6BK7-B	130	a) 52	57	0	6.3ac	130	57	57	0
V105	6BK7-B	250	—7.5	2.5	0	6.3ac	250	—7.5	0	0
					TIMING AND PULSE GENERATOR					
		NOTES: 6. Tube socket voltage variations are indicated as follows: a) Varies approximately 10 volts over range of TRIGGER POSITION VERNIER control b) Varies with V201 STAB (R206) c) Varies with 0.05 µsec (min pulse width adj) on front panel d) Varies with V203 STAB (R212) e) Varies with TURN-ON BTO BIAS (R257) f) Varies with µSEC (Pulse Width Vernier) control g) Varies with V207 STAB (R243) h) Varies with TURN-OFF BTO BIAS (R258)								
V201	6463	110	a) 37	a) 37	0	0	130	a) 37	b) 18	6.3ac
V202	6485	—7.5	0	0	6.3ac	130	130	0	.....	.....
V203	6463	110	c) 37	c) 37	0	0	130	c) 37	d) 18	6.3ac
V204	6BK7-B	250	—7.5	0	0	6.3ac	250	—7.5	0.5	0
V205	5687	250	e) —90	—45	0	0	12	—7.5	6.3ac	250
V206	5687	130	—45	0	0	0	0	—45	6.3ac	130
V207	6350	110	f) 37	f) 37	0	0	130	f) 37	g) 18	6.3ac
V208	6BK7-B	250	—7.5	0.1	0	6.3ac	250	—7.5	0	0
V209	5687	250	—7.5	12	0	0	2	h) —60	6.3ac	250
V210	5687	60	2	0	0	0	0	2	6.3ac	60

TABLE 4-4. VOLTAGE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
		PULSE DRIVER AND OUTPUT								
	NOTES: 6. Tube socket voltage variations are indicated as follows: a) Varies with DRIVER SCREEN ADJ (R302) b) Indicates plate cap reading—not pin 9 c) Varies with INVERTER BIAS (R343) d) Varies with DUTY CYCLE ADJ (R309) and with duty cycle while operating									
V301	6BX7-GT	a) 65	130	a) 70	a) 65	130	a) 70	0	6.3ac	.....
V302	6CB5	a) 70	0	0	0.75	0.75	0	6.3ac	a) 70	a, b) 45
V303	6CB5	a) 70	0	0	0.75	0.75	0	6.3ac	a) 70	a, b) 45
V304	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	..
V305	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	. .
V306	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	.....
V307	6AL5	.. ...	250	0	6.3ac	250	0	. ...	.....	
V308	6AL5	250	250	0	6.3ac	250	0	250	.. ...	.....
V309	5687WA	130	c) —10	0	0	0	0	c) —10	6.3ac	130
V310	5687WA	130	c) —10	0	0	0	0	c) —10	6.3ac	130
V311	6463	130	c) —10	c) —22*	0	0	130	c) —10	c) —22*	6.3ac
V312	12AT7	c) 22	c) 0.1	0	0	0	250	d) 10	d) 13	6.3ac
		POWER SUPPLY								
V501	6AS7-GA	230	340	250	230	340	250	0	6.3ac	.....
V502	12AX7	80	0	1	0	0	*155	*—0.6	1	6.3ac
V503	12AX7	230	—3	0	0	0	120	—1.5	0	6.3ac
V505	12AX7	80	0	1	0	0	*155	*—0.6	1	6.3ac
V506	0A2	0	—150	.....	—150	0	. ..	—150	. .	.....
V507	6AS7-GA	120	210	134	120	210	134	0	6.3ac	.....
V508	6AS7-GA	120	210	134	120	210	134	0	6.3ac	.....

TABLE 4-5
RESISTANCE MEASUREMENTS

NOTES: 1. All resistance measurements taken from tube socket to chassis
2. All resistance measurements are in ohms; K=thousand, M=million
3. Do not take readings immediately after turning off equipment

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
				SYNCHRONIZER						
		NOTES: 3. Tube socket resistance variations are indicated as follows: a) Varies with RATE VERNIER control setting b) Varies with meter polarity c) Varies with V104 STAB (R117) d) Varies with TRIG DELAY ADJ (R120)								
V101	6BK7-B	16K	a) 200K-2M	0	0.5	0.5	16K	a) 200K-2M	0	0
V102	12AT7	40K	390K	1K	0	0	4K	12K	13.K	0.5
V103	6AL5	b) 4K/20K	10K	0	0.5	b) 4K/20K	0	10K	-----	-----
V104	6BK7-B	10K	c) 22K-32K	5.6K	0	0.5	4K	d) 2M-4.5M	5.6K	0
V105	6BK7-B	15K	1.5K	470	0	0.5	15K	3.5K	0	0
				TIMING AND PULSE GENERATOR						
		NOTES: 4. Tube socket resistance variations are indicated as follows: a) Varies with TRIGGER POSITION VERNIER control setting b) Varies with V201 STAB (R206) c) Varies with 0.05 μsec (min pulse width adj) on front panel d) Depends on meter polarity e) Varies with V203 STAB (R212) f) Varies with PULSE WIDTH MULTIPLIER and μsec (Vernier) control settings g) Varies with V207 STAB (R243) h) Varies with TURN-OFF BTO BIAS (R258)								
V201	6463	5K	1.5K	a) 120K-600K	0	0	10K	1.6K	b) 0-250K	0.5
V202	6485	3.5K	0	0	0.5	4K	4K	0	-----	-----
V203	6463	5K	1.5K	c) 150K-200K	0	0	d) 4K/10K	1.6K	e) 0-25K	0.5
V204	6BK7-B	15K	3.5K	0	0	0.5	15K	1.3K	390	0
V205	5687	15K	7K	20K	0	0	1K	1.3K	0.5	15K
V206	5687	4.3K	20K	0	0	0	0	20K	0.5	4.3K
V207	6350	5K	1.5K	f) 150K-5M	0	0	d) 4K/10K	1.6K	a) 0-25K	0.5
V208	6BK7-B	15K	1.3K	47	0	0.5	15K	3.5K	0	0
V209	5687	15K	1.3K	1K	0	0	60K	h) 1.5K-7.5K	0.5	15K
V210	5687	15K	60K	0	0	0	0	60K	0.5	15K

TABLE 4-5. RESISTANCE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
					PULSE DRIVER AND OUTPUT					
	NOTES: 5. Tube socket resistance variations are indicated as follows: a) Indicates plate cap reading—not pin 9 b) Varies with DUTY CYCLE ADJ (R309)									
V301	6BK7-GT	18K	4K	Inf	18K	4K	Inf	0	0.5	.....
V302	6CB5	Inf	0	0	50K	50K	0	0.5	Inf	a) 4.3K
V303	6CB5	Inf	0	0	50K	50K	0	0.5	Inf	a) 4.3K
V304	6216	15K	4.5K	750	0	0.5	15K	Inf	750	.....
V305	6216	15K	4.5K	750	0	0.5	15K	Inf	750	.....
V306	6216	15K	4.5K	750	0	0.5	15K	Inf	750	.....
V307	6AL5	.....	15K	0	0.5	Inf	0	.....	.....	.....
V308	6AL5	Inf	15K	0	0.5	Inf	0	15K	.....	.....
V309	5687WA	4K	80K	0	0	0	0	80K	0.5	4K
V310	5687WA	4K	80K	0	0	0	0	80K	0.5	4K
V311	6463	4K	80K	60K	0	0	4K	80K	60K	0.5
V312	12AT7	45K	50K	0	0	0	15K	1M	b) 1K-3.5K	0.5
					POWER SUPPLY					
V501	6AS7-GA	1M	20K	15K	1M	20K	15K	0	0.5	.....
V502	12AX7	800K	0	400K	0	0	400K	200K	400 K	0.5
V503	12AX7	1M	1M	0	0	0	480 K	1M	0	0.5
V505	12AX7	800K	0	400K	0	0	400K	200K	400K	0.5
V506	OA2	0	10K	.....	10K	0	.....	10K	.....	.....
V507	6AS7-GA	471K	20K	4K	471K	20K	4K	0	0.5	.....
V508	6AS7-GA	471K	20K	4K	471K	20K	4K	0	0.5	.....

SECTION 5
ELECTRICAL PARTS LIST AND SCHEMATICS

Symbol	Part Number	Description
	BLOWER	
B501	8100 3501	motor ac, fan, 2-pole
—	8100 4201	blade
	CAPACITORS	
	(all capacitors are fixed, ceramic, 500 V unless otherwise specified)	
C101 to C104	0312 2430	0.02 μf, +100 —0%
C105	0316 2550	paper, 0.25 μf, ±10%, 400 V
C106	0305 5130	mica, 68 μμf, ±5%
C107	0302 9200	mica, 680 μμf, ±5%
C108	0302 9550	mica, 6800 μμf, ±10%, 300 V
C109	0317 7610	paper, 0.068 μf, ±5%, 200 V
C111	0317 7610	paper, 0.068 μf, ±5%, 200V
C112	0302 9550	mica, 6800 μμf, ±10%, 300 V
C113	0302 9200	mica, 680 μμf, ±5%
C114	0305 5130	mica, 68 μμf, ±5%
C115	0315 2010	150 μμf, ±20%
C116	0313 1040	paper, 0.5 μf, ±20%, 200V
C117	0305 5360	mica, 15 μμf, ±5%
C118	0316 2550	paper, 0.25 μf, ±10%, 400 V
C119	0315 2010	150 μμf, ±20%
C122	0312 2430	0.02 μf, +100 —0%
C123	0313 1040	paper, 0.5 μf, ±20%, 200 V
C124	0312 2430	0.02 μf, +100 —0%
C201	0313 1040	paper, 0.5 μf, ±20%, 200 V
C202	0305 5130	mica, 68 μμf, ±5%
C203 & C204	0315 6600	470 μμf, ±20%, 1000 V
C205	0315 2010	150 μμf, ±20%
C206	0315 6600	470 μμf, ±20%, 1000 V
C207	0315 0530	variable, 8-50 μμf, 350 V
C208	0315 6600	470 μμf, ±20%, 1000 V
C209	0315 2010	150 μμf, ±20%
C210	0302 1060	mica, 240 μμf, ±5%
C211	0315 2010	150 μμf, ±20%
C212	0312 2430	0.02 μf, +100 —0%
C213	0313 1040	paper, 0.5 μf, ±20%, 200 V
C214 & C215	0312 2430	0.02 μf, +100 —0%
C216	0305 5540	mica, 27 μμf, ±10%
C217	0316 2550	paper, 0.25 μf, ±10%, 400 V
C218 & C219	0315 0530	variable, 8-50 μμf, 350 V
C220	0302 0570	mica, 910 μμf, ±5%
C221	0315 0530	variable, 8-50 μμf, 350 V
C222	0305 5620	mica, 56 μμf, ±10%
C223	0315 0530	variable, 8-50 μμf, 350 V
C225 & C226	0315 6600	470 μμf, ±20%, 1000 V
C227	0315 2010	150 μμf, ±20%
C228	0313 1020	paper, 0.1 μf, ±20%, 200 V
C229	0312 2430	0.02 μf, +100 —0%
C230	0312 2430	0.02 μf, +100 —0%
C231	0313 1040	paper, 0.5 μf, ±20%, 200 V
C232	0312 2430	0.02 μf, +100 —0%
C233	0305 5540	mica, 27 μμf, ±10%
C234	0305 5090	mica, 47 μμf, ±5%
C301	0312 2430	0.02 μf, +100 —0%
C302	0301 9510	paper, 0.04 μf, ±20%, 200 V
C304	0300 3070	variable, 4-30 μμf
C305	0312 2430	0.02 μf, +100 —0%
C306 to C308	0318 6600	electrolytic, 1μf, 250 V
C309	0319 0071	electrolytic, 50 μf, 300 V
C310	0315 2010	150 μμf, ±20%
C311	0312 2430	0.02 μf, +100 —0%
C312	0319 0071	electrolytic, 50 μf, 300 V
C313	0300 3070	variable, 4-30 μμf
C314	0319 0071	electrolytic, 50 μf, 300 V
C315	0313 1040	paper, 0.5 μf, ±20%, 200 V
C316	0319 0061	electrolytic, 100 μf, 150 V
C317	0313 8780	electrolytic, 8 μf, 150 V
C318	0319 0061	electrolytic, 100 μf, 150 V
C401	0315 0530	variable, 8-50 μμf, 350 V
C501 & C502	0317 5860	electrolytic, 300 μf, 150 V
C503	0312 7620	paper, 0.1 μf, ±20%, 400 V
C504 to C507	0301 4460	electrolytic, 125 μf, +50 —10%, 350 V
C508	0312 7620	paper, 0.1 μf, ±20%, 400 V
C509	0311 6350	paper, 2 μf, ±5%, 600 V
C511 to C512	0301 4460	electrolytic, 125 μf, +50 —10%, 350 V
C513 to C515	0312 2430	0.02 μf, +100 —0%
C516	0317 2900	electrolytic, 4μf, +100 —0%, 350 V
	CONNECTOR	
—	0905 0850	adapter, line plug, 3-wire power connector to 2-prong female receptacle
	CRYSTALS	
CR101 & CR102	2600 1530	1N34A
CR201	2600 1530	1N34A
CR202	2600 0940	1N54A
CR203	2600 5170	1N307
CR204	2600 0940	1N44A
CR205	2600 5170	1N307
	RECTIFIERS	
	(metallic)	
CR501 & CR502	2600 2080	selenium, 400 ma
CR503 & CR504	2600 2110	selenium, plug-in type, 600 ma
CR505 & CR506	2600 5000	selenium, 50 ma
	DISTRIBUTED LINE	
DL301	8800 1451	delay line
	FUSES	
F501	1100 5250	6¼ ampere, slow blow (115-volt operation)
	1100 5210	3 ampere slow blow (230-volt operation)
F502	1100 1930	⅜ ampere
F503	1100 1900	1/16 ampere
	LAMPS	
DS301 & DS303	1200 0840	incandescent, miniature bayonet, 0.250 ampere

Symbol	Part Number	Description
DS305	1201 0041	neon indicator
DS501	1200 1370	incandescent, miniature bayonet, 0.250 ampere

RELAY

K301	0501 5321	armature, DPDT
K301	0500 9740	Armature, DPDT (Alternate)

INDUCTORS

L201	2101 3080	fixed, rf, 220 μh, ±10%
L301 & L302	2101 5482	variable, 1.3-2.6 μh

RESISTORS

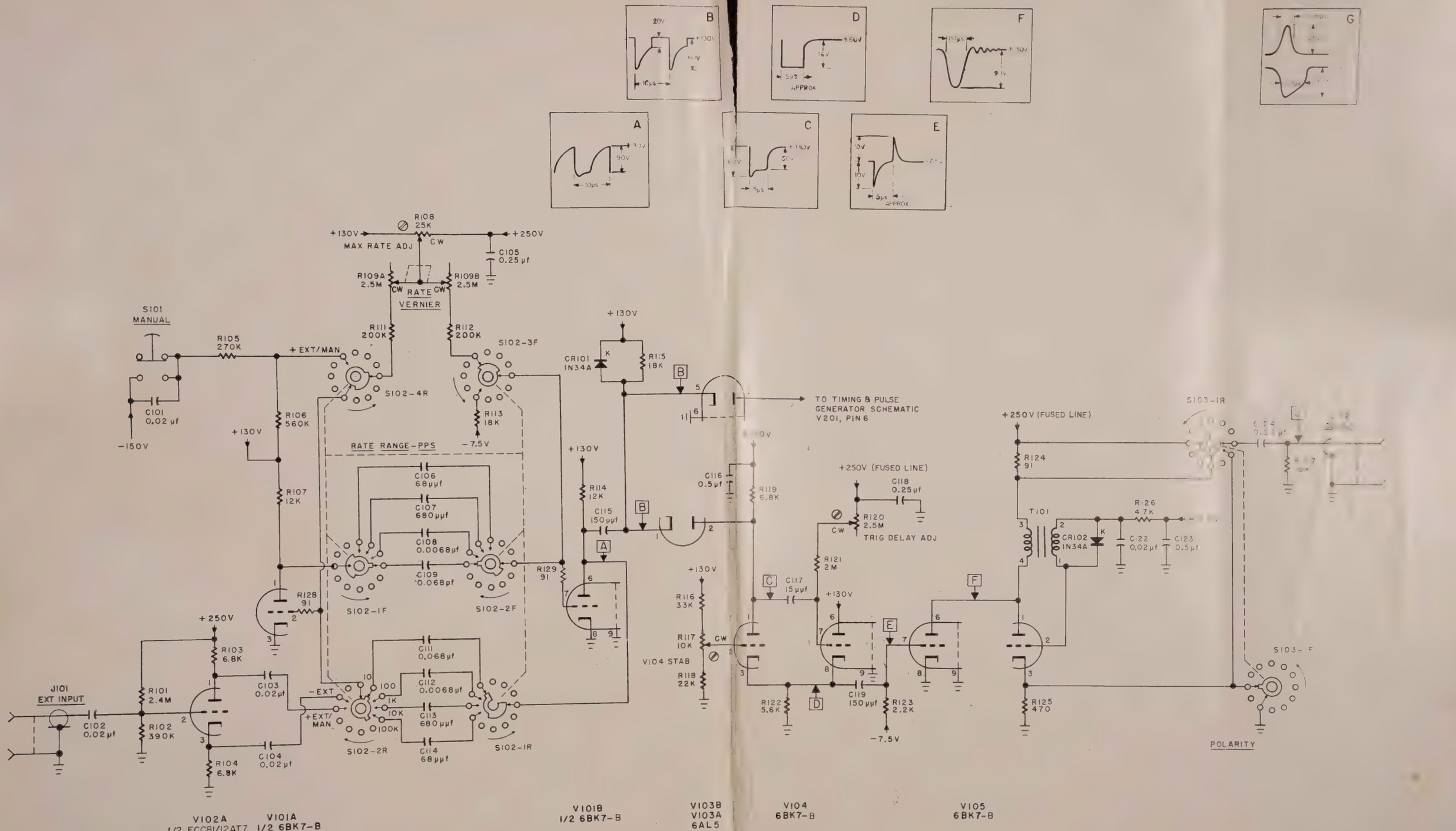
(All resistors are fixed, composition, ±10%, ½ W unless otherwise specified. Resistance value in ohms, K=thousand, M=million.)

R101	0203 1290	2.4M, ±5%
R102	0203 2080	390K
R103 & R104	0203 0680	6800 ±5%
R105	0203 2060	270K
R106	0203 2100	560K
R107	0203 3740	12K, ±5%, 1 W
R108	0101 4850	variable, 25K, ±20%, 2 W
R109 A, B	0107 1271	variable, 2.5M, ±20%, ¼ W
R111 & R112	0228 5910	film, 200K, ±1%
R113	0203 1920	18K
R114	0203 3740	12K, ±5%, 1 W
R115	0203 1920	18K
R116	0203 1950	33K
R117	0107 1023	variable, 10K, ±20%
R118	0203 1930	22K
R119	0203 1870	6800
R120	0107 1039	variable, 2.5M, ±25%
R121	0228 6230	film, 2M, ±1%
R122	0230 4580	wire wound, inductive, 5600 ±5%, 3 W
R123	0203 1810	2200
R124	0203 0230	91, ±5%
R125	0203 1730	470
R126	0203 1850	4700
R127	0203 1890	10K
R128 & R129	0203 0230	91, ±5%
R201, A, B	0107 0422	variable, 100K/1M, ±20%
R202	0203 1870	6800
R203	0228 5420	film, 120K, ±1%
R204	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R205	0203 1960	39K
R206	0107 1024	variable, 25K, ±20%
R207	0203 1650	100
R208	0230 4510	wire wound, inductive, 1500, ±5%, 3 W
R209	0203 1930	22K
R210	0203 2050	220 K
R211	0203 1960	39K
R212	0107 1024	variable, 25K, ±20%
R213	0203 1870	6800
R214	0105 6060	variable, 50K, ±20%, ¼ W
R215	0228 6280	film, 150K, ±1%
R216	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R217	0203 1650	100
R218	0230 4510	wire wound, inductive, 1500, ±5%, 3 W
R219	0203 1810	2200
R220	0203 1700	270
R221	0203 1720	390
R222	0203 1530	10
R223	0203 1570	22
R224	0232 6010	wire wound, 300, 15 W
R225 & R226	0203 6800	22K, ±5%, 2 W
R227	0203 0400	470, ±5%
R228 & R229	0232 6020	wire wound, 1K, 15 W
R230	0203 1530	10
R231	0203 7970	47K, 2 W
R232 A, B	0107 1261	variable, 10M, ±40%, ¼ W
R233	0203 2210	4.7M
R234 A, B, C	0107 1242	variable, 5M/2M/150K, ±30/20/10%
R235	0228 6260	film, 360K, ±1%
R236	0228 5420	film, 120K, ±1%
R237	0107 3900	variable, 10M, ±40%, ¼ W
R240	0203 1530	10
R241	0228 5420	film, 120K, ±1%
R242	0107 3900	variable, 10M, ±40%, ¼ W
R243	0107 1024	variable, 25K, ±20%
R244	0203 1960	39K
R245	0203 0770	16K, ±5%
R246	0203 1650	100
R247	0230 4510	wire wound, inductive, 1500, ±5%, 3 W
R248	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R249	0203 1810	2200
R251	0203 1610	47
R252	0203 1530	10
R253	0230 4630	wire wound, inductive, 10K, ±5%, 3 W
R254	0203 1770	1K
R255	0203 1570	22
R256	0203 1790	1500
R257 & R258	0101 4840	variable, 10K, ±20%, 2 W
R259	0203 1530	10
R261	0107 1024	variable, 25K, ±20%
R262	0203 2050	220K
R263 & R264	0203 1530	10
R265	0203 1810	2200
R266	0223 7620	film, 1.8M, ±1%
R267	0223 7400	film, 450K, ±1%
R268	0233 8030	film, 260K, ±1%
R301	0203 1930	22K
R302	0107 1024	variable, 25K, ±20%
R303	0203 1930	22K
R304	0230 4060	film, 1080, ±2%, 13 W
R305	0203 1990	68K
R306	0203 2130	1M
R307	0203 2070	330K
R308	0203 1770	1K
R309	0108 2850	variable, 5K, ±30%, 0.33 W
R310	0203 1980	56K
R311	0203 2250	10M
R312	0203 4970	47K, 1 W
R313 & R314	0203 1530	10
R315	0203 0310	200, ±5%
R316	0203 1530	10
R317	0203 1770	1K
R318	0203 0310	200, ±5%
R319	0203 1530	10
R320	0203 1770	1K
R321	0221 8040	wire wound, 750, ±5%, 10 W
R322	0203 1770	1K
R323	0203 0310	200, ±5%
R324	0203 1530	10
R325	0203 1770	1K
R326 & R327	0203 7550	15, 2 W
R328 & R329	0203 7530	10, 2 W
R330	0203 1840	3900
R331 & R332	0230 4050	film, 150, ±2%, 13 W
R333	0210 0650	wire wound, 1
R334	0211 3500	wire wound, 100, ±5%, 5 W
R335 & R336	0203 6310	200, ±5%, 2 W
R338	0203 0890	51K, ±5%
R339	0203 1000	150K, ±5%
R341	0203 1970	47K
R342	0203 1990	68K

section 5
parts list and schematics

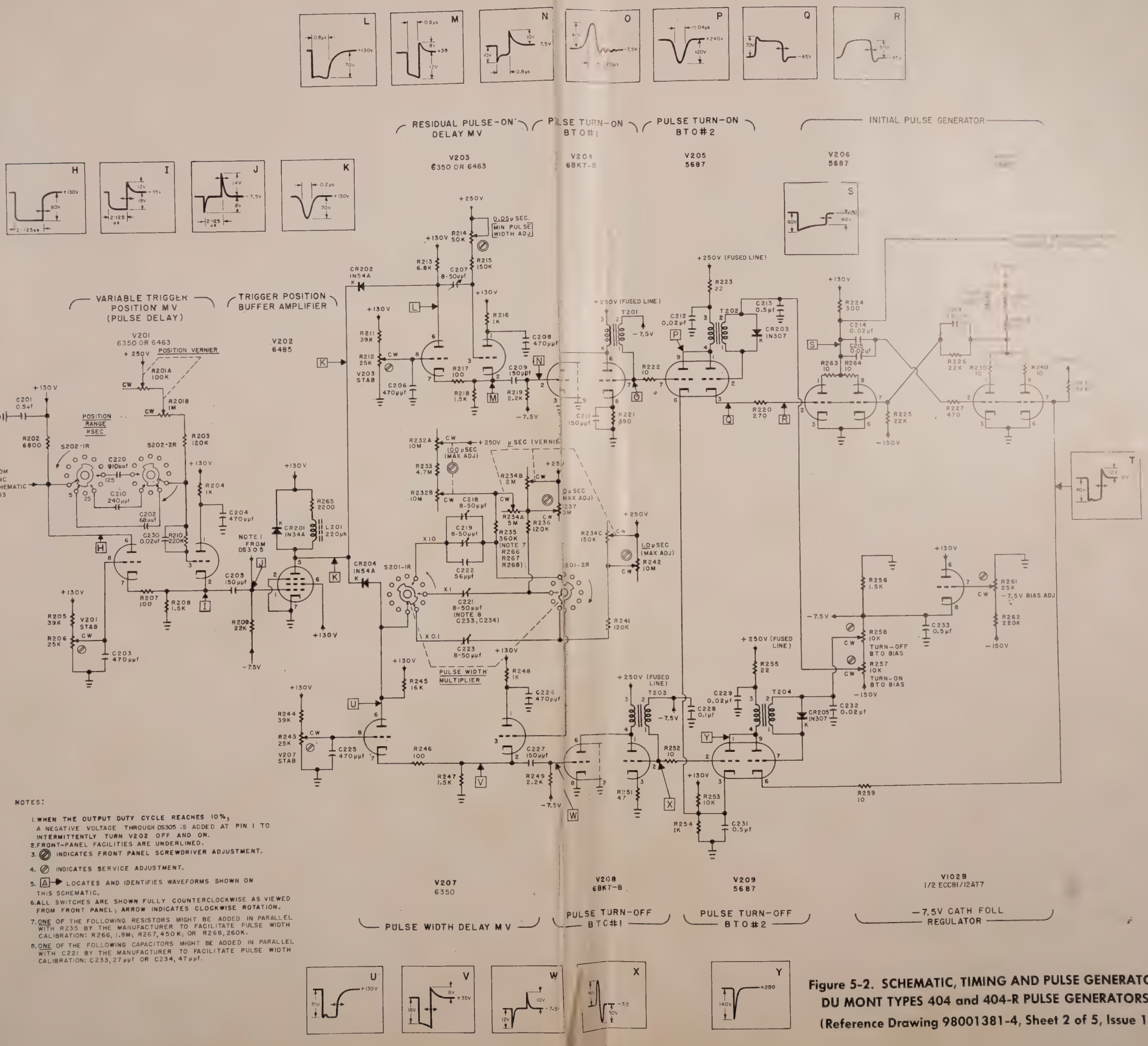
Symbol	Part Number	Description
R343	0108 2900	variable, 100K, ±30%, 0.5 W
R344	0203 1890	10K
R345	0203 2020	120K
R346 to R349	0203 1530	10
R351 to R354	0203 0230	91, ±5%
R401	0224 3490	film, 5.73, ±1%
R402	0228 8230	film, 215.2, ±1%
R403 & R404	0224 3490	film, 5.73, ±1%
R405	0228 8230	film, 215.2, ±1%
R406 & R407	0224 3490	film, 5.73, ±1%
R408	0228 8230	film, 215.2, ±1%
R409 & R410	0224 3490	film, 5.73, ±1%
R411	0228 8230	film, 215.2, ±1%
R412	0224 3490	film, 5.73, ±1%
R413	0224 3470	film, 2.87, ±1%
R414	0228 5400	film, 434, ±1%
R415	0224 3470	film, 2.87, ±1%
R416	0224 3430	film, 1.44, ±1%
R417	0228 5410	film, 868.3, ±1%
R418	0224 3430	film, 1.44, ±1%
R419	0228 8220	film, 96.25, ±1%
R420	0224 3500	film, 71.25, ±1%
R421	0228 8220	film, 96.25, ±1%
R422	0224 3500	film, 71.25, ±1%
R423 & R424	0228 8220	film, 96.25, ±1%
R425	0224 3500	film, 71.25, ±1%
R426 & R427	0228 8220	film, 96.25, ±1%
R428	0224 3500	film, 71.25, ±1%
R429 & R430	0228 8220	film, 96.25, ±1%
R431	0224 3550	film, 142.5, ±1%
R432	0230 4140	film, 96.25, ±1%, 4 W
R433	0224 3550	film, 142.5, ±1%
R434	0230 4140	film, 96.25, ±1%, 4 W
R501	0224 4640	wire wound, 750, ±5%, 55W
R502	0203 2130	1M
R503 & R504	0203 1730	470
R505	0203 1300	2.7M, ±5%
R506 & R507	0203 1530	10
R508	0203 1240	1.5M, ±5%
R509	0203 1190	910K, ±5%
R511 & R512	0203 1100	390K, ±5%
R513	0203 2010	100K
R514	0228 6040	film, 270K, ±1%
R515	0105 6050	variable, 25K, ±30%, ¼ W
R516	0228 5950	film, 160K, ±1%
R517	0230 4320	wire wound, inductive, 20, ±5%, 3 W
R518	0203 2090	470K
R519 & R520	0203 1770	1K
R521	0203 1300	2.7M, ±5%
R522	0224 4770	wire wound, 350, ±5%, 55 W
R523 & R524	0203 3080	22, ±5%, 1 W
R525	0203 1240	1.5M, ±5%
R526	0203 1190	910K, ±5%
R527 & R528	0203 1100	390K, ±5%
R529	0203 2010	100K
R531	0228 6280	film, 150K, ±1%
R532	0105 6050	variable, 25K, ±30%, ¼ W
R533	0228 5970	film, 160K, ±1%
R534	0203 1570	22
R535 & R536	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R537 & R538	0203 1770	1 K
R539 & R540	0203 3080	22, ±5%, 1 W

Symbol	Part Number	Description
SWITCHES		
(All rotary switches are phenolic and the angle of throw is 60° between positions unless otherwise specified)		
S101	0500 6793	push-push
S102	0501 1911	rotary, 30°, 4 sections, 6 positions
S103	0501 1921	rotary, 1 section, 3 positions
S201 & S202	0501 1971	rotary, 2 sections, 3 positions
S301	0501 1921	rotary, 1 section, 3 positions
S401 to S406	0500 6793	push-push
S407	0501 1901	rotary, 2 sections, 6 positions
S501	0500 1130	toggle, SPST
TRANSFORMERS		
T101	2001 1080	pulse
T201	2002 0000	pulse
T202	2001 1080	pulse
T203 & T204	2002 0000	pulse
T501	2000 9983	plate
T502	2000 9973	filament
TUBES		
V101	2500 1540	6BK7-B
V102	2500 1530	12AT7
V103	2500 0020	6AL5
V104 & V105	2500 1540	6BK7-B
V201	2501 1010	6463
—	2501 1510	6350 (alternate)
V202	2500 9100	6485
V203	2501 1010	6463
—	2501 1510	6350 (alternate)
V204	2500 9100	6BK7-B
V205 & V206	2500 2950	5687
V207	2501 1510	6350
V208	2500 1540	6BK7-B
V209 & V210	2500 2950	5687
V301	2500 7810	6BX7-GT
V302 & V303	2501 1190	6CB5-A
V304 to V306	2501 0250	6216
V307 & V308	2500 0020	6AL5
V309 & V310	2500 4690	5687 WA
V311	2501 1010	6463
—	2501 1510	6350 (alternate)
V312	2500 1690	ECC81/12AT7
—	2501 1530	12AT7 (alternate)
V501	2501 0200	6AS7-GA
V502 & V503	2501 1680	ECC83/12AX7
V505	2501 1680	ECC83/12AX7
—	2500 1500	12AX7 (alternate)
V506	2500 0300	0A2
V507 & V508	2501 0200	6AS7-GA
CABLE		
W501	5026 9641	assembly, power, #18/2 AWG, 72 inches



NOTES: 1. FRONT-PANEL FACILITIES ARE UNDERLINED.
2. ⊘ INDICATES SERVICE ADJUSTMENT.
3. ALL SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE AS VIEWED FROM FRONT PANEL; ARROW INDICATES CLOCKWISE ROTATION.
4. [A]→ LOCATES AND IDENTIFIES WAVEFORMS ON THIS SCHEMATIC.

Figure 5-1. SCHEMATIC, SYNCHRONIZER
DU MONT TYPES 404 and 404-R PULSE GENERATORS
(Reference Drawing 98001381-4, Sheet 1 of 5, Issue 7)



NOTES:

1. WHEN THE OUTPUT DUTY CYCLE REACHES 10%, A NEGATIVE VOLTAGE THROUGH DS305 IS ADDED AT PIN 1 TO INTERMITTENTLY TURN V202 OFF AND ON.
2. FRONT-PANEL FACILITIES ARE UNDERLINED.
3. ⊘ INDICATES FRONT PANEL SCREWDRIVER ADJUSTMENT.
4. ⊘ INDICATES SERVICE ADJUSTMENT.
5. [A]→ LOCATES AND IDENTIFIES WAVEFORMS SHOWN ON THIS SCHEMATIC.
6. ALL SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE AS VIEWED FROM FRONT PANEL; ARROW INDICATES CLOCKWISE ROTATION.
7. ONE OF THE FOLLOWING RESISTORS MIGHT BE ADDED IN PARALLEL WITH R235 BY THE MANUFACTURER TO FACILITATE PULSE WIDTH CALIBRATION: R266, 1.8M; R267, 450K; OR R268, 260K.
8. ONE OF THE FOLLOWING CAPACITORS MIGHT BE ADDED IN PARALLEL WITH C221 BY THE MANUFACTURER TO FACILITATE PULSE WIDTH CALIBRATION: C233, 27μμf OR C234, 47μμf.

Figure 5-2. SCHEMATIC, TIMING AND PULSE GENERATOR DU MONT TYPES 404 and 404-R PULSE GENERATORS

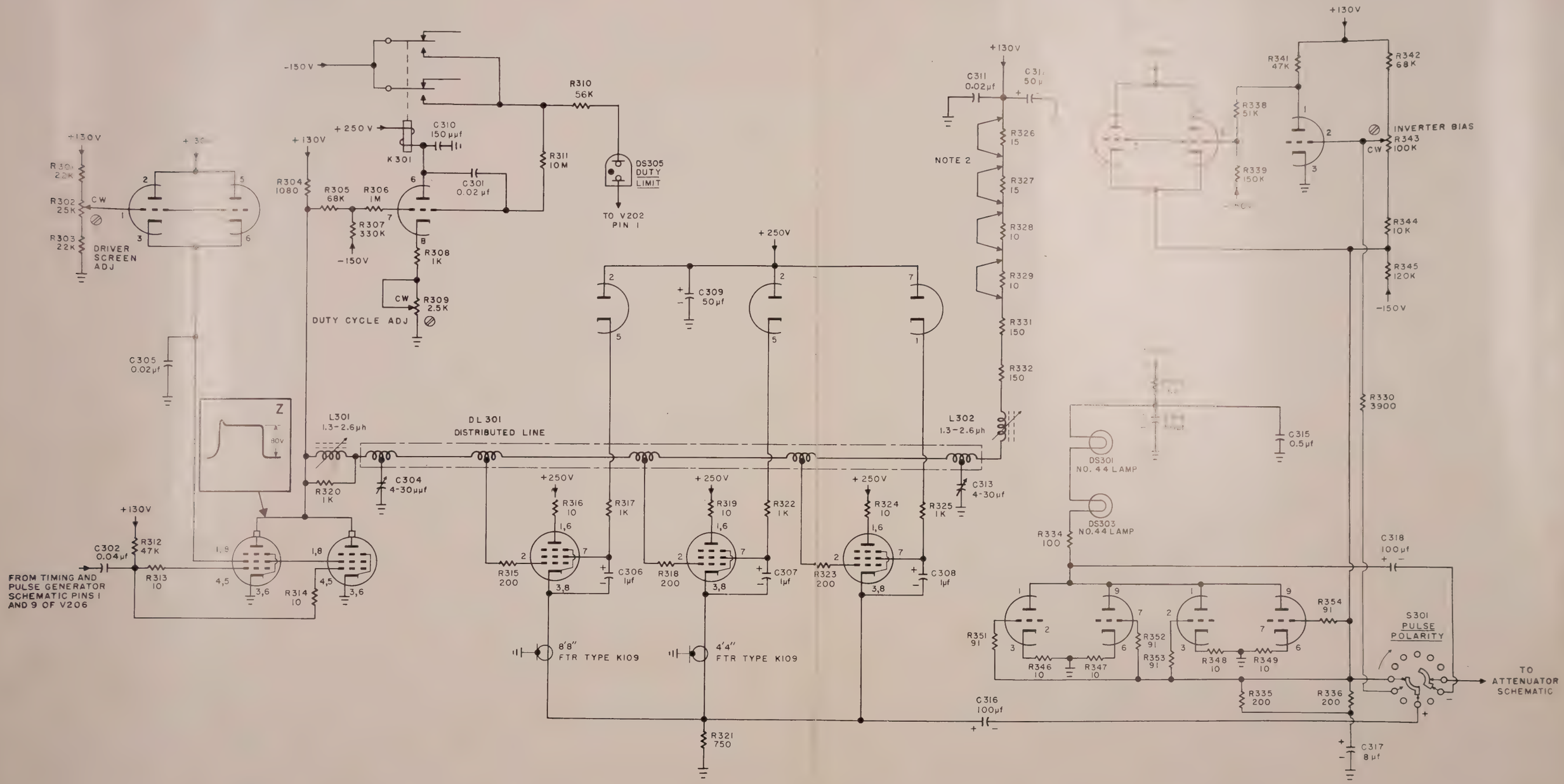
(Reference Drawing 98001381-4, Sheet 2 of 5, Issue 13)

DRIVER SCREEN GRID REGULATOR — V301 6BX7-GT

DUTY CYCLE LIMIT — V312B 1/2 ECC81/12AT7

CF SCREEN BOOTSTRAPPED DIODES — V307B 1/2 6AL5; V308A 1/2 6AL5; V308B 1/2 6AL5

PHASE INVERTER BIAS REGULATOR — V312A 1/2 ECC81/12AT7



V302 6CB5-A; V303 6CB5-A — DRIVERS

V304 6216; V305 6216; V306 6216 — DISTRIBUTED CATHODE FOLLOWERS

V309 5687WA; V310 5687WA — OUTPUT PHASE INVERTER

NOTES- 1. ⊘ INDICATES SERVICE ADJUSTMENT
2. JUMPERS ACROSS R326 THROUGH R329 ARE ADDED OR OMITTED WHERE NECESSARY TO OBTAIN THE PROPER TERMINATION FOR DL 301
3. FRONT-PANEL FACILITIES ARE UNDERLINED

Figure 5-3. SCHEMATIC, PULSE DRIVER AND OUTPUT DU MONT TYPES 404 and 404-R PULSE GENERATORS
(Reference Drawing 98001381-4, Sheet 3 of 5, Issue 12)

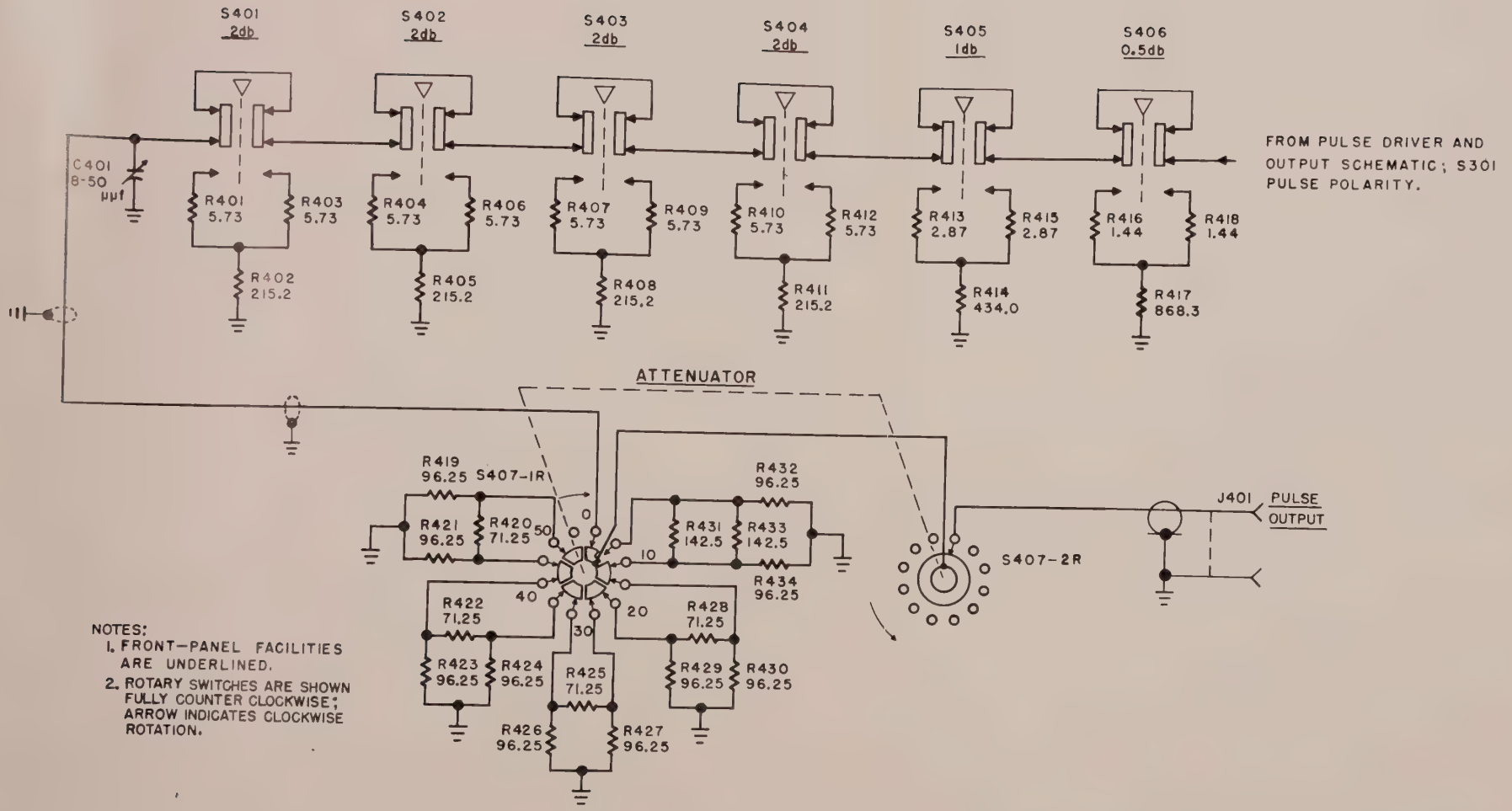


Figure 5-4. SCHEMATIC, OUTPUT ATTENUATOR DU MONT TYPES 404 and 404-R PULSE GENERATORS (Reference Drawing 98001381-4, Sheet 4 of 5, Issue 2)

JUMPER WIRING
FOR LINE VOLTAGE CONVERSION

FOR 115V OPERATION

FOR 230V OPERATION

S501 ON

F501 FOR 115V 6.25A FOR 230V 3A

W501 115/230V 50-60~ 600VA

B501 FAN

BLK

BLK-YEL

YEL

GRY

WHT

T501

BLUE

BLUE

CR501 ST400

CR502 ST400

C501 300µf

C502 300µf

F502 3/8 A

C504 125µf

R517 20

RD-BK

CR503 ST609

RD-YL

RD-BK

CR504 ST609

C505 125µf

C506 125µf

C507 125µf

+250V

R501 750

R502 1M

R503 470

R504 470

R505 2.7M

-150V

R506 10

R507 10

R508 1.5M

R509 910K

R512 390K

C503 0.1µf

R514 270K

F503 1/16 A

+250V

+250V (FUSED LINE)

C516 4µf

+250V ADJ

R515 25K

CW

R513 100K

R511 390K

-150V

R516 160K

-150V

R522 350

R519 1K

R523 22

V507 6AS7-GA

R520 1K

R524 22

+130V

V505 ECC83/12AX7

R537 1K

R539 22

+250V

R526 910K

R528 390K

C508 0.1µf

R531 150K

+130V ADJ

R540 22

R518 470K

R538 1K

V503 B 1/2 ECC83/12AX7

V508 6AS7-GA

R525 1.5M

R521 2.7M

-150V

R532 25K

CW

R529 100K

R527 390K

R533 180K

-150V

V506 0A2

C509 2µf

CR506 ST 50

R535 1K

R536 1K

-150V

CR505 ST50

C511 125µf

R534 22

C512 125µf

C513 0.02µf

GRY

YEL

BLK-YEL

BLK

WHT

T502

GN

GN

DS501 NO.44 LAMP

C514 0.02µf

C515 0.02µf

5687WA	6AS7-GA	6216	6485	6CB5-A	5687	6463	6216	6BK7-B	6350
V309 V310	V501 V507 V508	V304 V306	V202	V302 V303	V205 V206 V209 V210	V201 V203 V311	V305	V104	V207

6AL5 V103 V317 V318

6BK7-B

ECC83/12AX7 V502 V503 V505

ECC81/12AT7 V[illegible] V[illegible]

Figure 5-5. SCHEMATIC, POWER SUPPLY AND HEATER CIRCUITS DU MONT TYPES 404 and 404-R PULSE GENERATORS

(Reference Drawing 98001381-4, Sheet 5 of 5, Issue 13)

WARRANTY AND SERVICE NOTICE
for
Industrial Instruments

DU MONT INSTRUMENTS

Each instrument manufactured by the Technical Products Division of Allen B. Du Mont Laboratories, Inc., is guaranteed to equal or exceed its published performance specifications. It is further guaranteed against defective materials (other than the cathode-ray tube) and workmanship for a period of one year from delivery date. Any defective instrument or an instrument that does not meet or exceed our specifications will, upon inspection by us, be repaired or replaced at our discretion should such defect appear within the guarantee period.

Industrial type cathode-ray tubes used in Du Mont industrial instruments are guaranteed for 1000 hours of operation or for a six-month period from date of shipment, whichever expires first. Adjustments will be made on the merit of each individual claim because of the widely varying applications to which such tubes are subjected, and a tube which becomes defective during the guarantee period will be replaced ONLY AFTER INSPECTION AT THE FACTORY. Cathode-ray tubes returned under the guarantee, must be shipped with transportation paid.

SPECIAL GUARANTEE FOR 400 SERIES INSTRUMENTS

All instruments in the Du Mont 400 Series have an additional guarantee as follows: Printed wiring and transformers for a period of five years; cathode-ray tubes for a period of one year from date of shipment.

REGISTERING THE GUARANTEE

To register this guarantee, the enclosed guarantee card must be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information is necessary. BOTH THE TYPE NUMBER AND THE SERIAL NUMBER OF THE INSTRUMENT MUST BE GIVEN ON THIS CARD.

Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold, or to supply new equipment in accordance with earlier specifications excepting under the classification of special apparatus.

SERVICE

In order to insure factory service under our guarantees, the guarantee cards enclosed with all instruments and tubes must be properly filled out and returned. In all cases where service or adjustment is requested, please write first to the factory giving complete information concerning the nature of the failure and describing the manner in which the equipment was used when failure occurred. THE TYPE NUMBER AND SERIAL NUMBER of the equipment must also be given. In this way, much time can be saved and unnecessary inconvenience often avoided. When writing in this respect, address:

Allen B. Du Mont Laboratories, Inc.
Instrument Service Department
760 Bloomfield Avenue, Clifton, New Jersey

The Instrument Service Department will then send to the customer the written procedure for disposition, and shipping instructions. All equipment should be packed and shipped in accordance with this procedure; and identification tags should be attached to each tube or instrument.

REPLACEMENT PARTS

If it is necessary to order a replacement component from the factory, always give the type number and serial number of the instrument and refer to the component by its symbol designation and description on the circuit schematic. This will help to expedite service.

ALLEN B. DU MONT LABORATORIES, INC. Technical Products Division
760 Bloomfield Avenue Clifton, New Jersey

DU MONT

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TECHNICAL PRODUCTS DIVISION

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